ELEMENTS OF HYGIENE AND PUBLIC HEALTH

FOR THE USE OF MEDICAL STUDENTS AND PRACTITIONERS

BY

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WITH AN INTRODUCTION BY

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THIRD EDITION, REVISED AND ENLARGED.

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This Book is Dedicated

TO

LIEUT.-COL. E. J. O'MEARA,

F.R.C.S. (Eng.), D.P.H. (Camb.), I.M.S.,
Principal, Agra Medical School.

AS A MARK OF RESPECT AND IN ADMIRATION
OF HIS KEEN INTEREST IN MEDICAL
EDUCATION.

BY THE AUTHOR.

PREFACE TO THE THIRD EDITION.

ALL the copies of the second edition and its new impression having been sold out it has been found necessary to publish the third edition. Every effort has been made to bring the present edition up to date by making necessary additions and alterations in all the chapters. New sections on Filariasis, Trypanosomiasis, Phlebotomus Fever, Hookworm Disease, Anthrax, Maternity and Child Welfare have been introduced, and a new chapter on Venereal Diseases has also been added to the text.

I have great pleasure in acknowledging my obligation to Mr. D. N. Chatterji, B.A., B.Sc., A.I.C., Chemical Examiner to the Governments of United and Central Provinces, for writing out the section on the Bacteriological Examination of Water, and to Rai Bahadur Dr. Jai Gopal Mukarji, Reader in Pathology, Faculty of Medicine, Lucknow University, for revising the chapters on Infectious Diseases.

I wish also to express my thanks to Lieut.-Col. W. Clemesha, C.I.E., M.D., I.M.S., the Director, School of Tropical Medicine and Hygiene, Calcutta, Messrs. H. K. Lewis and Company, London, Messrs. Paterson Engineering Co., Ltd., Calcutta, the Empire Engineering Co., Cawnpore, and Messrs. Thacker Spink and Co., Calcutta, for allowing me the use of their blocks and diagrams for some illustrations in the text.

Lucknow,
September, 1928. J. P. MODI.

PREFACE TO THE SECOND EDITION.

I HAVE been much gratified at the very favourable reception accorded to the first edition of this book. This has resulted in the publication of a second edition within a short space of time.

I have taken the opportunity of carefully revising the book, so that it can be adopted as a text-book in the Medical Colleges of India. Hence, though nominally a second edition of "Elements of Hygiene and Public Health," this is, generally speaking, almost a new book. Several chapters have been amplified and rewritten. New chapters on industrial hygiene, occupational diseases, offensive trades, hospitals, school hygiene, and some infectious diseases have been added. As a practical guide to the sanitary inspectors and health officers the model bye-laws have been given as an appendix at the end.

I have endeavoured to adopt some of the valuable suggestions offered by my friends, as well as contained in the reviews which appeared in the medical press on the publication of the book. I desire to express my best thanks for the assistance received from my friend, Honourary Captain K.V. Amin, D.P.H., Health Officer of Ahmedabad. I am also indebted to Mr. H.M. Rogers, of Messrs. Butterworth and Company, Calcutta, for helping me in correcting the proofs.

J. P. MODI.

Lucknow, 1920.

PREFACE TO THE FIRST EDITION.

THIS book has been written in response to a demand from the medical students for a text-book on Hygiene and Public Health. As a lecturer on this subject for over ten years in one of the largest medical schools in India, I always found that the students were very much handicapped in their study of such an important subject for want of a proper text-book suitable to their needs. With a view to supplement that want this book has been written, mostly in accordance with the Syllabus laid down for the qualifying examination of "L.M.P." by the State Board of United Provinces for Medical Examinations.

I do not pretend any originality in this book except the way in which the facts and certain subjects have been so arranged as can be easily understood by the class of students for whom it is meant ; but I must admit that the subject-matter has been largely borrowed from various text-books, periodicals, etc., to the authors of which I am very grateful ; and a list of these has been appended at the end of the book.

Two special chapters on village sanitation, fairs and famine camps have been written with a view to enlighten the would-be Sub-Assistant Surgeons, as they are the proper persons to carry the torchlight of modern sanitation to villages and that they should know the rules and regulations, which are ordinarily required of them when on fair or famine duty.

I must acknowledge my thanks to Col. O'Meara and Prof. Pandya for their having gone through the manuscript and for their-valuable suggestions — to Col. O'Meara especially, for without his encouragement this book—my humble attempt—would never have seen the light of day.

Agra, 1918. THE AUTHOR.

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THERE are many books on European Hygiene, which are not adaptable or suitable to the conditions existing in India and the East; there is, therefore, a great demand for a small practical book such as Dr. Modi has written, based on the Syllabus of the largest medical school in India.

Dr. Modi has a long experience of teaching, having been a lecturer for over ten years, and the book is the outcome of repeated demands from students and practitioners for a concise book on Hygiene and Public Health, treated from the Indian standpoint, especially as regards food, malaria, plague, cholera and dysentery.

I would invite attention to the chapters on Village Sanitation, a question of vital importance in this country as affecting the health of the great majority of the people and a subject which has not been so fully dealt with in any previous work on Hygiene. The sanitary arrangements for fairs, the chief cause of the spread of cholera in Northern India, is another important chapter, also the measures recommended for famine and segregation camps.

In conclusion, I have much pleasure in congratulating Dr. Modi on the energy and public spirit he has shown in compiling this excellent little book.

CHAPTER I.

WATER.

WATER is a prime necessity of life, not only as an article of diet but also for the proper cleanliness of person, clothing and things. Without it there would be no life, animal or vegetable. It forms about two-thirds by weight of the human body. Water exists in three states, *viz.*, solid, liquid and gaseous. As a solid it is met with in the form of snow and ice; as a liquid it is met with in the sea, in rain, in streams, rivers and lakes; while as a gas or vapour, it forms one of the constituents of the atmospheric air, and of the breath which we exhale from our lungs.

Water is a chemical compound, consisting of two atoms of hydrogen and one of oxygen (H_2O), and is formed whenever hydrogen, or a combustible substance containing hydrogen, is burnt. Water forms an exception to the general law that bodies expand when heated and contract when cooled, for during the act of freezing it expands nearly one-eleventh of its volume. It solidifies or freezes forming ice at 0°C., and exhibits its greatest density at 4°C. Water boils at 100°C. under the ordinary atmospheric pressure of 760 mm. of mercury, and is converted into an invisible vapour, which occupies about 1600 times the volume that the water did. But it boils at a lower temperature at high altitudes where the barometric pressure is less than at the sea level. It is practically incompressible and an extremely bad conductor of heat.

It is very difficult to obtain water chemically pure, but for practical purposes water that has the following characteristics may be taken as pure :—

(1) It should be clear, transparent, tasteless and inodorous; it should be colourless in small quantities, but greenish blue through a deep column,

(2) It should not contain an undue amount of solid constituents, specially when such constituents are lime and magnesia. The amoant of solids should not exceed 8 grains per gallon, one grain of which should be dissipated by heat.

(3) It should be practically free from nitrogenous organic matter. Any sample of water, which along with a considerable quantity of free ammonia, yields 0.05 parts of albuminoid ammonia per million, should be viewed with suspicion.

(4) There should be a certain lustre or sparkle indicating the presence of carbon dioxide gas.

(5) Above all it should be sterile, i.e., free from all sorts of bacteria.

SOURCES OF WATER.

The natural sources of water are rain and snow falling on the surface of the earth ; but a common classification is as follows :—

(1) Rain water; (2) Surface water, including lakes, streams and rivers ; and (3) Ground water, including springs and wells.

(1) RAIN WATER.

This is produced by the condensation of aqueous vapour present in the air, derived from the surface of vast sheets of water by evaporation. It is the clearest and purest of waters, but during its downward progress it absorbs various gases and suspended solid particles from the air. Rain water, therefore, varies with the purity of the atmosphere through which it has passed. It contains, on an average, about 25 c.c. of dissolved gases per litre, of which the chief are 64 per cent. nitrogen, 34 per cent. oxygen, and 2 per cent. carbonic acid. In addition, it contains usually ammonia. In sea-coast towns rain water contains sodium chloride as an impurity, and in large manufacturing towns and cities of inland districts it is found to contain nitrites, nitrates, nitrous and nitric acids, sulphurous and sulphuric acids, sulphates, sooty particles, a

large number of bacteria, and the pollen of grasses and flowers. Besides, rain water may contain microscopic plants, e.g., *Protococcus pluvialis*, spores of fungi and dust derived from volcanic regions and sandy deserts, and may appear coloured if the latter two impurities are present in a large quantity.

Part of the rain that falls is at once evaporated or absorbed by vegetation, part flows along the ground surface to form rivers and lakes, and the remainder percolates through the interstices of the soil until it reaches an impervious stratum. The amount of rain water that percolates through the soil depends chiefly on the nature of the soil. Scarcely any rain water percolates through a clayey soil, while about 20 per cent. of rainfall passes through a soil consisting of limestone, 40 per cent. through chalk, and approximately 90 per cent. through a sandy and gravelly soil. The nature and slope of the soil, the season of the year and the amount of rainfall are the chief factors in calculating the relative amounts of the three portions. On an average $\frac{6}{10}$ths of the actual rainfall are available for storage.

Rain water is ordinarily collected from the surface of the roofs, and stored in masonry tanks or small reservoirs sunk below the ground level in some part of the house. These tanks should be built on a bed of concrete, lined on the inside with hydraulic cement and surrounded externally with at least a foot of well puddled clay so as to prevent the entrance of surface or sub-soil water. Such water is, however, liable to be much polluted with soot, vegetable and animal matter being washed off from the surface of the roofs, especially the tiled ones. It is, therefore, necessary to reject the first part of a rainfall, and to collect and store it after the roofs have been thoroughly washed. Any mechanical arrangement, such as Robert's or Gibb's Rain Water Separator, for letting the washings may be attached to the rain water pipe. It is so ingeniously arranged that it allows the first part of the rainfall to run to waste but, after a time, tips over and directs

the remainder into the collecting channel and reservoir. Sir William MacGregor has introduced an arrangement by which clean water can be stored, and can also be protected from mosquito eggs and larvæ. The amount of water that can be collected from a roof can be estimated by the following formula :—

The area of a roof in square feet multiplied by half the amount of rainfall in inches equals gallons of water per year.

In calculating the surface of a roof its slope need not be taken into account, but the flat surface actually covered by the roof.

When rain water is required for a small population as in a prison, military camp, etc., it should first be received on a large area of the ground constructed of concrete or other impervious material, and then conveyed into underground reservoirs by means of pipes. This ground, which is known as *catchment area*, must be kept scrupulously clean, and well protected by an impassable fence to keep away animals. No cultivation of the land should be allowed, nor should habitations be allowed within the area. The supply channel to the tank from the catchment area should be frequently inspected and kept clean.

As a source of domestic supply rain water is unreliable owing to the uncertainty of rainfall, and the length of the dry season in some localities.

Rain water is specially useful for cooking and washing as it is soft water, *i.e.*, it does not contain salts of calcium and magnesium dissolved in it. These salts when dissolved in water give to it the property of " hardness ", and, acting upon the soap, prevent the formation of a lather. Hence, there is a great waste of soap if hard water is used for washing. Hard water also is not good for culinary purposes, as meat and vegetable material, if cooked by boiling in hard water, get hardened.

The hardness of water may be *temporary* or *permanent* according to the solubility of the salts contained in it.

Temporary hardness is due to the soluble acid carbonates of calcium and magnesium in water. Permanent hardness is, on the other hand, caused by the presence of sulphates and chlorides especially of calcium and magnesium.

Temporary hardness can be removed and water rendered soft by the following three methods :—

1. Boiling.
2. Clark's Process.
3. Permutit System.

1. **Boiling**.—Boiling drives off CO_2 as gas and converts the soluble acid carbonates into insoluble carbonates, and throws them down as a white precipitate, which gradually collects on the bottom of the containing vessel and forms what is known as the "furring" of kettles. In the case of the calcium salt the chemical reaction is represented by the following equation :—

$$CaH_2(CO_3)_2 + \text{Heat} = H_2O + CO_2 + CaCO_3.$$

Calcium acid (bi) carbonate (soluble) — Calcium carbonate (insoluble)

2. **Clark's Process**.—In this process lime in the form of milk of lime or fresh slaked lime is added to water so that the soluble calcium salt is converted into the insoluble carbonate which precipitates and falls to the bottom.

The chemical reaction in this case is represented by the following equations :—

a. $Ca(H_2CO_3)_2 + CaO = H_2O + 2\,CaCO_3.$

b. $Ca(H_2CO_3)_2 + Ca(OH)_2 = 2\,H_2O + 2\,CaCO_3.$

3. **Permutit System**.—This is a recently invented system for the softening of water, and is useful for domestic purposes. This is based upon the fact that if water containing calcium carbonate is allowed to filter through a stratum of certain silicates containing sodium silicate, an exchange of bases takes place so that calcium silicate, which is an

insoluble salt remains in the filter and the sodium carbonate, a soluble salt, passes in the water. The equation representing the reaction is as follows :—

$$Ca\ CO_3 + Na_2\ Si\ O_4 = Ca\ Si\ O_4 + Na_2\ CO_3.$$

Silicates employed in this system are synthetically prepared and sold in the market as *permutit*. When this substance is exhausted during the process, it may be regenerated by passing a ten per cent. solution of salt through the filter when the soluble calcium and magnesium chlorides pass away and sodium permutit is reformed which is again ready for use.

Permanent hardness cannot be removed by boiling, as the salts causing hardness are stable compounds. It may, however, be reduced by the addition of sodium hydroxide or sodium carbonate, depending upon the degree of hardness.

(2) SURFACE WATER.

This is rain water which has run over the surface of a soil without penetrating it, and has formed lakes, impounding reservoirs, streams and rivers.

Lakes.—These are natural reservoirs from which a great many places in India obtain their water supply. When collected from unpopulated, hilly or mountainous districts, such water affords an excellent supply, being usually soft and containing but little chlorine. It does not contain ammonia, nitrates and nitrites more than are usually found in rain water. It, however, contains more dissolved matter than rain water. On the other hand, the water collected from low land surfaces usually contains much peaty matter, as well as phosphates and nitrates washed from the manures of cultivated fields, and becomes yellow or brownish in appearance.

Impounding Reservoirs.—These are artificial ponds or lakes, usually made by building a dam or barrier across the narrow valley. They are frequently made along the course of a small stream. These are constructed by excavations or embankments. The embankments should be of great strength

to bear the tremendous pressure of water behind them, and should be made of puddled clay on the inside, and their sloping sides should be covered with dressed stones bedded with hydraulic cement on the inner side and with grass on the outer side. They should be of such a size as to contain a sufficient quantity of water to supply the population of the district for a period of 150 to 180 or more days. The chief points to be taken into consideration in providing reservoirs are the amount of water to be supplied per head per day, the size of the catchment area, the minimum annual rainfall, the proportion of annual rainfall available for storage, and the longest period of continuous drought. According to Hawksley's rule the average rainfall of twenty years less one-third corresponds to the amount of rain in the driest year; while the average of twenty years plus one-third gives the amount of rain in the wettest year. The total quantity yielded by a catchment area may be calculated by Pole's formula, *viz.*, $Q=62A(\frac{4}{5}R-E)$, where Q = the total yield of water in gallons; A = the size of the catchment area or gathering ground in acres; R = the mean rainfall of the three driest consecutive years; and E = the loss of water by evaporation, waste and percolation; this varies from 10 to 20 inches.

The chief sanitary advantage of these impounding reservoirs is that most pathogenic bacteria die a natural death during storage, and according to A. C. Houston four weeks are sufficient to produce this result. However, owing to their being stagnant, and open to air and light they favour the growth and subsequent decay of algæ, which give the water a bad taste and foul smell. This is rendered harmless by treating it with copper sulphate, hung in a piece of cloth from the sides of a boat, which is rowed on the surface of the reservoir.

In addition to impounding reservoirs compensation reservoirs must be constructed into which at least one-third of the total quantity impounded and collected during heavy rainfall can be directed, and afterwards allowed to pass down the stream for the use of millowners, etc.

Rivers.—The nature and amount of the impurities found in river water will depend upon the strata over which the water flows and upon the nature of the surface. It is frequently muddy, and contains solid matter in suspension. Rivers generally form the natural drainage channels of the surrounding land and towns situated on their banks, and thus are always liable to be polluted by sewage, refuse and the dead bodies of men and animals. But the water is naturally purified to a certain extent by oxidation due to sunlight, by deposition and by dilution. Hence the shallow and small rivers, which usually dry in the summer, are dangerous from a sanitary point of view.

In estimating the water supply of a community from a river or stream the average yield of a stream may be roughly estimated by selecting some fifteen yards of the stream when the channel is fairly uniform and free from eddies. Measure its breadth and depth at several places and take the average. By multiplying these two averages together the sectional area is obtained. Drop in a chip of wood and note the time it takes to travel over the selected distance, say, 30 feet. From this the surface velocity can be calculated in feet per second. Four-fifths of this will give the mean velocity, and this multiplied by the sectional area will give the yield per second in cubic feet of water.

(3) GROUND WATER.

Water which, having fallen as rain, has percolated through the permeable layers of the soil down to the impermeable layer, is known as ground water, and forms another source of water supply in the form of springs and wells. This water is greatly purified, as it undergoes natural filtration during its passage through the soil. It, however, absorbs a large quantity of carbon dioxide from the ground air. Water, thus acidulated, is capable of dissolving lime and other mineral constituents, so that the ground water is apt to be harder than the surface water.

Springs.—These are natural outcrops or overflows of the underground water, where the geological formation is favourable. They are commonly found on the side or foot of a hill, in valleys, in the bed of a river, lake, or sea. Springs are usually classified as land or superficial and main or deep springs.

Land springs are formed by water percolating through the porous layers of sand or gravel overlying an impervious stratum of clay, and are the outlets of the limited collections of the underground water. They are unsatisfactory as a source of water supply, as they are often intermittent, ceasing to flow during the driest period of the year.

Main or deep springs are those, which, as a result of hydrostatic pressure, issue through fissures or cracks from regular geological formations, such as chalk, green sand, sandstone and oolite. The water of these springs is clear and sparkling, and is generally safer, having been filtered in its passage through the earth, and the flow is also constant. The water can, however, be contaminated from surface washings and manure containing human excreta. As a safeguard against such contamination the spring should be protected above with a masonry or concrete wall, and a ditch should be dug around its sides to carry off the surface water, and the neighbourhood kept clear of weeds. Grass should be planted about the spring so as to keep out dust, and prevent erosion of the soil. Animals should not be allowed to come near the spring, and stables and latrines should not be located in the near vicinity. If necessary, they may be constructed on another slope.

The yield of a spring may easily be determined by noting the time which it takes to fill a vessel of known capacity, *e.g.*, a 30-gallon cask.

Spring waters possessing medicinal properties or a saline taste are known as mineral waters. Their water is unfit for ordinary drinking purposes. There are several springs of this nature in India. The mineral springs containing sulphuretted hydrogen and various sulphides in solution are referred to as

sulphur springs ; waters containing iron or magnesium sulphate in solution are known as chalybeate or magnesia waters.

Wells.—There are three kinds of wells—shallow, deep and artesian. Shallow or surface wells are those that have a depth of less than 50 feet, and are not carried through an impervious stratum. They draw their supply from sub-soil or ground water. Deep wells tap the water-bearing stratum beneath the impervious stratum, and are usually 100 feet or more in depth. These wells are known as Artesian wells—from the province of Artois in France—when they are sunk through impervious strata into a water-bearing stratum where the water is under such a head of pressure as to cause it to overflow to the surface. Artesian wells may contain large quantities of calcium sulphate and alkaline carbonates.

Wells furnish water supplies to most of the villages and towns in India. Shallow wells may yield good water, provided there is no risk of pollution from surface washings or

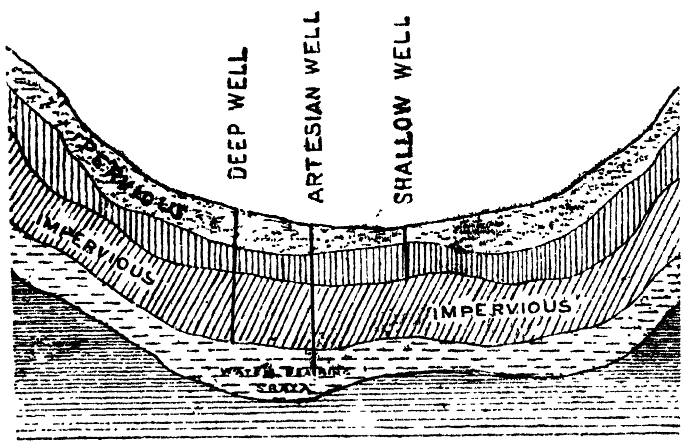

Fig. 1—Soils and Wells.

from their proximity to drains and cesspools, but too much reliance cannot be put on these, and so it is always safe to take water from deep wells, the sides of which are protected by steining with brick and cement up to a level below that of

the sub-soil water. This brick work should be carried to at least about a foot above the ground level.

Detection of the Source of Pollution of a Well.—To ascertain if a cesspool or collection of sewage actually drains into a well, fluorescein may be added to it, and after a time its presence may be detected in the well water. One-quarter to half a pound of the fluorescein dissolved in water and added to the suspected source of contamination will be detected in the well water by giving it a fluorescent tint, if it is present in the proportion of only one part to 100 million parts of water. It should be remembered that fluorescein does not give any colour to the acid water. Hence caustic potash should be added, if the water is acid, which is, however, a rare occurrence. Instead of fluorescein a large amount (10 lbs.) of ammonium or sodium chloride may be added to the source of contamination, but in this case the chlorine content of the water should be ascertained before and after the addition. Similarly, cultures of the Bacillus prodigiosus will be found rearing in the well water, if they have passed through it from the suspected source of pollution. Lastly, kerosene oil may be poured on the ground to find out if there is any direct drainage from the surface to the well.

Examination of a Well.—In the examination of a well the following points should receive attention :—

1. The leakage and position of a well.
2. The depth of water in a well.
3. The distance from the surface.
4. The effect of pumping.
5. The surroundings and distances from possible sources of pollution.
6. The nature of the soil.
7. The method of disposal of waste water.

Yield of a Well.—The test for calculating the yield of a well consists in lowering the level of its water to a considerable depth by pumping, and noting the rise of water in it at intervals of 15 or 30 minutes.

Tube Wells.—These are commonly known as Norton's Abyssinian tube wells, and are used when a temporary supply

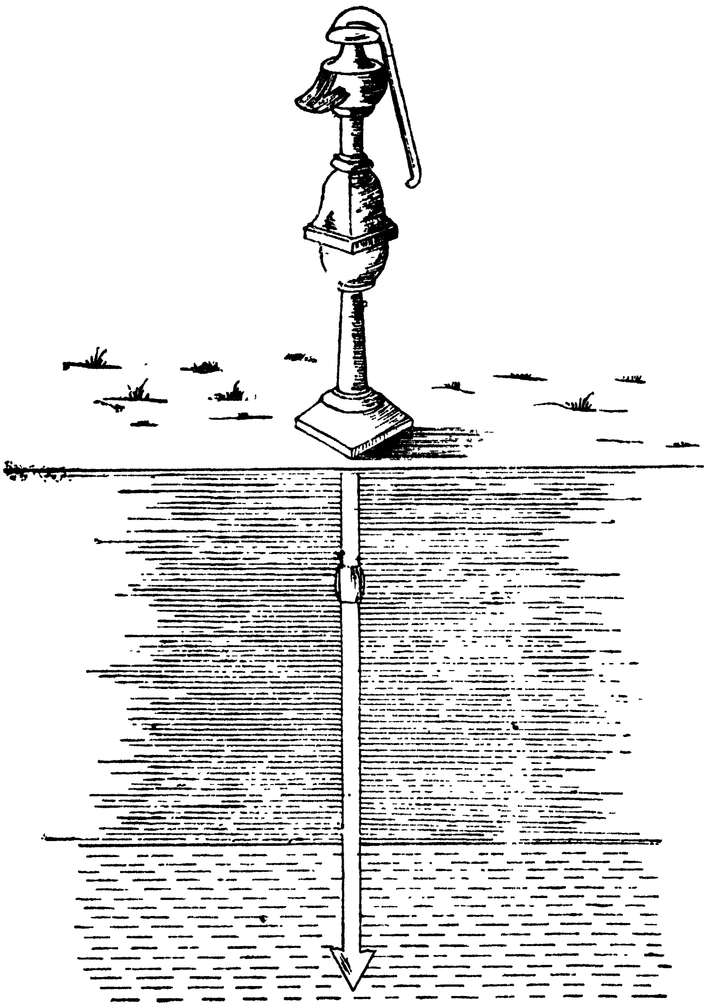

Fig. 2—Abyssinian Tube Well.

of water is required, as in famine camps, in big fairs or for the army in times of war. They are made by driving into the soil lengths of hollow cast-iron tubes having a diameter of $1\frac{3}{4}$ to 3 inches, which are screwed together, the lowest being pointed and perforated with holes, until a good supply is struck. The water may be obtained by attaching a pump to the top of the tube. The pump yields on an average about 7 gallons per minute. The water pumped at first is turbid, but soon becomes clear, if the pumping is continued. The advantages of the tube wells are that they prevent pollution from surface contamination, do not allow mosquitoes to reach, and can be shifted from place to place.

These wells are useful in loose gravelly soils, especially when the depth is about 25 feet or so. They are largely used in the Punjab, and other provinces, where the conditions of the soil favour their use.

Comparison of Waters derived from different Sources.—The Rivers Pollution Commissioners classify the qualities of these waters as follows :—

(*a*) Wholesome	1. Spring water. 2. Deep well water.	Very palatable.
(*b*) Suspicious	3. Upland surface water. 4. Stored rain water.	Moderately palatable.
(*c*) Dangerous	5. Ordinary surface water from cultivated lands. 6. River water to which sewage gains access. 7. Shallow well water.	Palatable.

Quantity of Water Needed.—The quantity of water required by individuals depends upon their habits and the season of the year. In cold climate a less amount of water is necessary than in the tropical. Water is required for drinking, cooking, personal ablutions, washing clothes and utensils and for other domestic purposes. Besides these, for calculation

of the water supply of big towns and cities, allowance should always be made for watering roads, cleaning surface drains and latrines, extinguishing fires, and that required for horses and other animals, as also for mills, factories, parks and gardens. Roughly 30 gallons of water a day per head may be considered sufficient for all these purposes. The following table shows the average amount of water allowed per head per day in the under-mentioned towns in India :—

Bombay	...	40 gallons.
Calcutta	...	35 gallons.
Madras	...	18 gallons.
Allahabad	...	21.85 gallons.
Cawnpore	...	29 gallons.
Benares	...	29.71 gallons.
Lucknow	...	15.71 gallons.
Agra	...	24.06 gallons.

In hospitals a very much larger quantity is required, and generally the amount used is double the ordinary supply, the average being 40 to 50 gallons per head.

An adult male drinks, on an average, 50 to 60 ounces of water daily, exclusive of the amount contained in his so-called solid food, but this quantity even varies according to the season and occupation. Women and children drink less water. The quantity needed for animals also varies according to the food, season and exertion. The amount required for cows and oxen varies from 5 to 6 gallons a day and that for ponies and horses from 6 to 8 gallons.

Storage of Water.—Water required for household purposes should always be stored in clean and bright copper or brass vessels, which must be kept covered so as to prevent dirt and dust from falling in. They should not be placed under staircases, for dust is likely to fall in when someone is moving on the stairs. These vessels should not be kept in bath rooms, otherwise foul gases may be absorbed. Water in these vessels is likely to get hot in summer, and so, to keep drinking water cool, it is necessary to use *Surais* or earthen

vessels. But these are likely to absorb injurious gases owing to the pores in them, therefore they should be changed very often, or it is still better to use glazed earthenware vessels, such as *Matkas* or *Gharas*. Wooden tubs should never be used to store water as they get rotten and decayed very soon.

DISEASES CAUSED BY IMPURE WATER (WATER-BORNE DISEASES).

The diseases which are contracted by the use of impure water are dyspepsia and diarrhœa, dysentery, enteric fever, cholera, goitre, parasitic diseases, and metallic poisoning.

Dyspepsia and Diarrhoea.—Permanently hard waters often cause dyspeptic symptoms and diarrhœa especially among the new-comers, as the residents of the locality obtain a certain amount of immunity by habitually drinking such water. The chlorides, sulphates and nitrates of calcium or magnesium are the more injurious salts. Similar symptoms are produced from brackish water drawn from wells near the sea coast. Such waters contain a larger excess of chlorides of sodium, calcium and magnesium. Mica suspended in water is supposed to cause sprue. Temporary hard waters are not injurious at all. Water polluted with sewage produces diarrhœa, often of a severe choleraic type with violent purging, vomiting and cramps. Infantile diarrhœa, so often fatal in summer, is due to water pollution in some cases. Vegetable matter, such as peat in water, is generally harmless but, if present in large excess, may produce diarrhœa.

Dysentery.—This may be spread by the evacuations of patients suffering from this disease contaminating the water used for drinking purposes.

Enteric Fever.—This is more often spread through the medium of water than by any other means. It oftentimes happens, that water already contaminated by the evacuations of patients suffering from this disease is consumed by quite healthy individuals causing them to fall ill. It

should also be noted that enteric fever is known to have been spread by the use of swimming baths fed with polluted sea water. Schistosomiasis and spirochætal jaundice may also be spread by bathing in contaminated rivers and canals.

Cholera.—This is, as a rule, propagated by drinking water to which the specific disease poison has had access. Sometimes it is spread by taking food in utensils washed in a tank or a lake contaminated by this poison.

Goitre.—This disease is supposed to be caused by drinking water derived from limestone and dolomitic rocks. But from the researches conducted in the districts of Chitral and Gilgit Major Mc Carrison, I.M.S., has proved that endemic goitre is caused by a living micro-organism which gaining access to the intestinal tract of man emanates a toxic substance that has a specific action of causing simple enlargement of the thyroid gland. This micro-organism resides in the soil and is conveyed to man through water contaminated by passing over such soil. According to him the ideal conditions for the development of goitre are to be found in a country district with an agricultural population living on a porous soil, which soil contains much organic matter and by virtue of its porosity or slope admits of the ready passage of the organic matter into the unprotected streams and wells, that are chiefly the water supply of the people.[1]

Parasitic Diseases.—The embryos or eggs of the following parasitic worms are often found in water, and may be taken into the stomach of man, when such water is used for drinking :—

Taenia solium (Tape-worms), **Bothriocephalus latus, Ascaris lumbricoides** (Round worms), **Oxyuris vermicularis** (Thread-worms), **Filaria sanguinis hominis, Bilharzia haematobium**, **Ankylostoma duodenalis, Distoma hepaticoma** and **Filaria dracunculus** (Guinea-worm).

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1. Lancet, Jany. 18, 1913, p. 147, Jany. 25, 1913, p. 219 and Feb. 8, 1913, p. 365.

Leeches when swallowed in water may fix themselves in the pharynx, and cause hæmorrhage.

Metallic Poisoning.—This may be caused by drinking water contaminated with trade refuse and drainage from metalliferous mines. Lead poisoning is a common occurrence when drinking water is contaminated with it by using lead service pipes or lead cisterns and tanks for distributing, collecting and storing water. In this connection it should be remembered that soft waters having an acid reaction and containing nitrates or nitrites in solution or carbonic acid in excess have a remarkable solvent action on lead. The oxygen dissolved in water combines with lead and forms oxide of lead, which being soluble in water causes contamination. On the other hand hard waters containing carbonates or sulphates are not apt to absorb lead as they form insoluble salts of lead which form a protecting coating on the surface of the metal and prevent a further action of the water on lead.

Lastly it should be remembered that glanders, foot and mouth disease, anthrax and tuberculosis may be communicated to animals through the use of contaminated water troughs.

PURIFICATION AND DISTRIBUTION OF WATER.

Since impure water has been found to be a source of so many diseases, it is essential to purify water by removing unpleasant odours, turbidity, excessive hardness, suspended impurities of an organic and inorganic nature, and all objectionable bacteria as well as other bacteria before it is consumed by the people. For this purpose municipalities have constructed water works for the supply of pure water to the community in several towns and cities. Where this has not been possible, people should purify water in their houses, before it is consumed by them.

Purification on a large scale.—This is carried out by filtration and sterilization.

Filtration.—For this purpose two forms of filters are now in common use—(1) slow sand filters, (2) rapid mechanical filters.

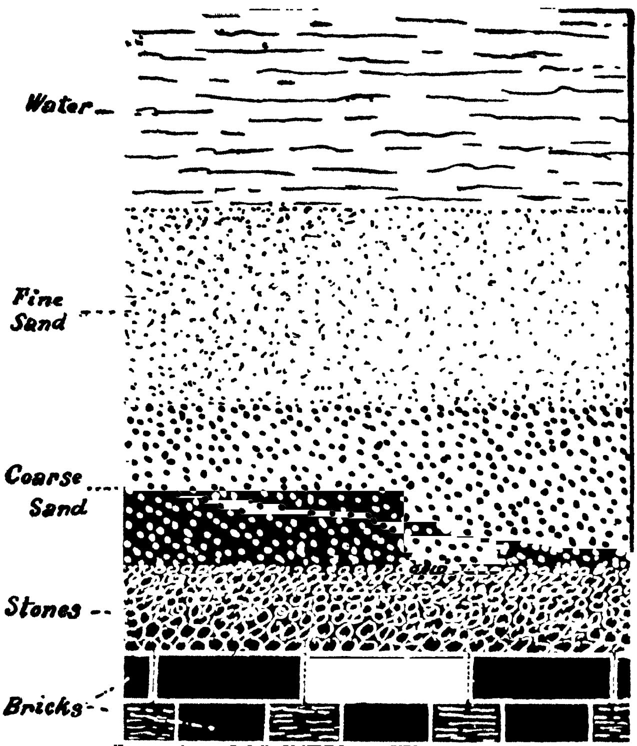

Fig. 3—Filtering Tank.

1. **Slow Sand Filters.**—Raw water is first collected and stored into large open reservoirs, commonly known as settling tanks, where solid matters in suspension gravitate to the bottom. These consist of sand and mineral grit, and clay in fine subdivision and form a deposit on the bottom of the tank, which has to be removed by scraping from time to time. From his recent experiments Dr. Houston, Director of Water Examination, Metropolitan Water Board, has shown

that owing to sedimentation, oxidation and sunlight disease-producing micro-organisms are mostly destroyed if water is allowed to remain for thirty days in the settling tanks. But he does not suggest the supercession of filtration. He recommends both storage and filtration.

After a period varying from twenty-four to forty-eight hours the water from these tanks is passed on to the surface of sand filters generally known as English filter-beds, as they were first used in England. They consist of open or covered large rectangular water-tight tanks usually built of brick lined with cement. At the bottom of these beds two layers of dry bricks placed one above the other on edge, are arranged in the form of drains and channels for the passage of the filtered water. Above these bricks and in the spaces between the bricks is placed a layer of six inches of broken stone or pebbles, size being one and a half inches cube. On the top of these there is another layer of small stones or pebbles filling up the empty spaces. On the stones is supported the filtering material consisting of coarse sand, four to six inches in thickness, and of fine sharp sand, thirty to thirty-six inches in thickness. The coarse sand should pass through a one-sixteenth inch mesh screen and fine sand through a one-sixtieth inch mesh but not through a one-eightieth inch mesh. Sand is either taken from the sea-shore, from river banks or from sand banks. The depth of the water above the sand is usually thirty-six inches. In most European filters the depth varies between thirty-six and fifty-two inches. In Bombay it is about thirty-six to forty-two inches and in Lucknow it is usually forty-two inches. To ensure a uniform rate of filtration these filter-beds are also provided with valves at the inlets and outlets.

The action of filtration is slightly chemical and largely mechanical. The organic matter present in water is oxidized by the presence of air and nitrifying micro-organisms in the sand, but the mechanical effect is more important.

The solid particles which had not settled to the bottom in the first tank (settling tank) are usually held up in the sandy layers of the second (filter-bed). After the filter has been in use for two or three days, a thin slimy gelatinous layer of a zoogleal mass consisting of algæ, fungi, and other low vegetable organisms is formed upon the surface and between the superficial particles of sand. It is this layer which effectively retains the bacteria of the water. Practically this vital gelatinous layer is the most important factor in purifying water in these filter-beds, hence it is not disturbed as long as filtration is not obstructed. However, after some time the layer becomes thicker, and the water cannot pass through it except very slowly; it then becomes necessary to remove the soiled layer of the sand about half an inch in thickness, which is washed with filtered water and stored in boxes, and then replaced, when the sand layer reaches a depth of about twelve inches.

For efficient filtration of water through these filter-beds the rate of flow should not exceed four inches per hour. In India the rate of flow usually does not exceed thirty to thirty-six gallons per square foot in twenty-four hours. As a rule ninety-six to ninety-eight per cent. of bacteria present in the unfiltered water are removed, and the water is rendered quite fit for drinking purposes if the filter-beds are properly constructed and duly looked after. In this type of filters the rate of flow may be allowed to exceed fifty gallons per square foot of the surface per twenty-four hours, if the unfiltered water has previously been allowed to pass through a roughing filter *i.e.*, a coarse filter which holds back the suspended matter, solids, algæ, etc., and leaves the bacteria for the slow filter to retain. In this case the slimy layer will take more time to form, but once formed the water can be safely allowed to pass through the filtering medium at an increased rate of seventy to eighty gallons per square foot per twenty-four hours. The rate of flow may also be increased if the filtered water has afterwards to be treated with

chlorine or its compound. The filtered water should not contain more than one hundred micro-organisms in one cubic centimeter. Hence it is very essential that a bacteriological examination of water should be conducted when a filter is being made ready for use so as to make sure that a larger number of micro-organisms is not passing into the effluent.

The Puech-Chabal System.—This is a French system of slow sand filtration which is used to purify turbid water especially due to the presence of certain particles of clay sufficiently fine to pass through a sand filter. In this system raw water is first passed through a series of roughing filters containing gravel of diminishing degrees of coarseness and situated in tiers placed one above the other. From these roughing filters which are known as *dé grossisseurs* of Puech and Chabal the water is allowed to flow into prefilters resembling ordinary sand filters but containing coarse sand with granules one-eighth inch in diameter on an average. With the head of three feet the water flows through these filters at four or five times the rate usual in slow sand filters. Passing through the roughing and prefilters it parts with all suspended impurities in the form of organic matter, algæ, etc., and is then led to the finishing filters, where it is deprived of the bacteria. Finishing filters do not require to be scraped for a long period of six to nine months.

Raw water that has first passed through the Puech-Chabal filters may be allowed to flow with safety through the ordinary slow sand filter at a rapid rate of 120 gallons per square foot per 24 hours. Hence these filters are very useful in cities where a very large quantity of water is required every day. They have recently been introduced in Cawnpore, but owing to the initial high cost many municipalities cannot adopt this system of filtration of water.

Rapid Mechanical Filters.—Owing to the expense, care and time required in their cleaning and resting, and large tracts of land required for their construction the slow sand

filters have been much criticized. Hence mechanical filters have been devised. These are less expensive, simple and easy in manipulation, and require a very small area of ground. They are always fixed inside a covered shed or room, and consist of large wooden, iron, or concrete cylinders or tanks about 7 feet deep containing a filtering medium of crushed quartz or sand, 4 or 5 feet in thickness supported on broken stone or pebbles. These cylinders may be covered or uncovered. If covered, they are known as pressure filters and if uncovered, they are called gravity filters. They are well suited for purifying muddy river waters. They are also called American filters as they were first introduced into America. Only recently they have been introduced into Lucknow, Poona, Bombay, Dehli and other large cities in India.

The mechanical filters are capable of filtering at a very high rate of 100 to 130 gallons per square foot per 24 hours. 100,000,000 gallons per acre may be considered as a daily average.

The essential feature of these mechanical filters is to add a chemical coagulant to the water for forming a slimy layer and then to pass it rapidly through a filtering medium of sand. The coagulant used is aluminium sulphate which acting with the alkaline earths present in the water produces a flocculent, gelatinous precipitate of aluminium hydroxide. The equation representing the chemical reaction is as follows :—

$$Al_2(SO_4)_3 + 3\ Ca(H\ CO_3)_2 = Al_2(OH)_6 + 3\ Ca\ SO_4 + 6\ CO_2.$$

It is necessary that there should be sufficient calcium bicarbonate in water to break up the aluminium sulphate. But, if it is deficient or absent as in peaty waters, a suitable proportion of lime or soda must be added to the water. The precipitated aluminium hydroxide forms a sticky, gelatinous film on the top of the filtering sand, and serves the same purpose in holding back and arresting the passage of fine suspended matter and micro-organisms in the water through the filtering medium as the vital gelatinous layer forming on the surface of the slow sand filter.

Alum in amounts varying from half to one or two grains per gallon according to the nature of water is usually added by means of special gear to raw water collected in a settling tank, and is thoroughly mixed in its passage along the mixing trough to the far end of the coagulating tank. Water is allowed to stand here for a few hours, so that the chemical reaction may be completed and a large portion of the precipitate may carry with it grosser impurities to the bottom. The water thus clarified partially and containing a small portion of the flocculent precipitate is forced through the top of the filters at high pressure, and in passing through the filtering material of sand loses its dirt, colour and about 95 to 98 per cent. of its micro-organisms. The bacterial purification, however, is not so constant and uniformally high as that obtained by slow sand filtration. Hence as a further safe guard the filtered water is nowadays submitted to a further process of purification by chlorine.

Owing to the high rate of filtration which may reach 150 inches or more per hour, the filtering medium becomes loaded with micro-silt, organic matter, and bacteria which interfere with the efficiency of the filters as seen by the discharge getting gradually reduced. Mechanical filters, therefore, require frequent cleansing, the frequency varying according to the quality of the water and the season of the year. In Lucknow mechanical filters are cleansed every 36 to 48 hours in the rainy season, and every 120 hours in summer.

Cleansing of the filters is effected by shutting off the inlet valve and passing a reverse current of filtered water from the clean water reservoir through the bottom of the sand bed and simultaneously stirring up the sand by means of rotating metal arms or rakes or a blast of compressed air or steam. The filtered wash water flows away to waste over the top. A thorough cleansing of a mechanical filter is carried out in about 15 to 20 minutes and a satisfactory film of the precipitate is formed in a further period of 20 minutes. On the contrary about 30 men are required to clean slow sand filters in eight hours,

Types of Rapid Mechanical Filters.—The chief types of rapid mechanical filters in common use are Paterson Filter, Jewell Filter, Bell's Patent Filter, and Candy Filter.

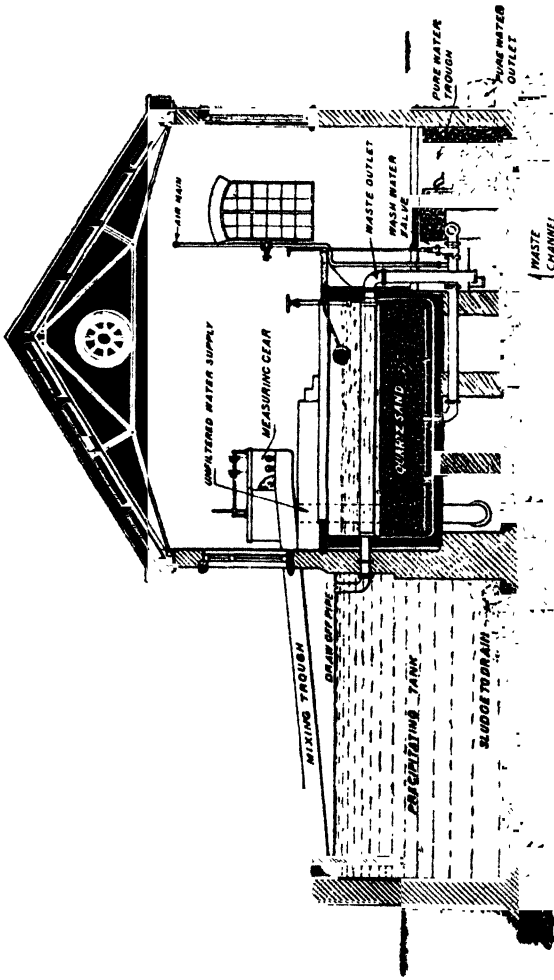

Fig. 4—Paterson's Rapid Mechanical Filter.
(From The Paterson Engineering Co., Ltd.).

Paterson Filter.—This type of filters has recently been introduced for the purification of drinking water into

many large cities of India, such as Bombay, Dehli, Poona, Lucknow, etc. In this type there is always an arrangement of treating the filtered water with chlorine.

In this type of filters raw water is first brought into a cement masonry open conduit where a solution of aluminium sulphate is poured and mixed as the water travels along the conduit to the precipitation tanks. The raw water mixed with the alum solution takes generally four and a half hours (in Lucknow) to pass the precipitation tanks before it comes on the rapid filter, which contains three feet of water above the sand bed consisting of sand of 40 mesh, 30 inches in thickness. Graded pebbles are placed under the sand to prevent it from getting to the bottom. On the bottom are kept inverted brass strainers which collect the filtered water and convey it through pipes into a regulating valve and from there to an inspection chamber where it passes over a weir into the chlorinating chamber.

Chlorination is effected by a patent machine with regulating valves and a pulsator which is regulated in such a manner as to supply a constant quantity of chlorine gas. After passing the pulsator seal chlorine meets the filtered water in a porcelain chamber and is conveyed by a pipe to the chlorinating chamber, where it meets the effluent from each filter, mixes with it and purifies it.

These filters do not, like slow sand filters, show a progressive improvement in the quality of filtered water but attain their maximum efficiency within an hour of their start, and that thereafter no further improvement takes place. It is ordinarily considered essential that a constant and continuous supply of alum be maintained throughout the entire period of the working of the filter. But Major A. D. Stewart,[1] I.M.S., has found from his investigations that the filters work perfectly well even if the dosage of alum is discontinued after the filter

1. Tropical School of Medicine, Annual Report., 1924, p. 51.

has reached its maximum efficiency, provided the raw water is not actually turbid and has had some sedimentation to free it from gross suspended impurities.

Jewell Filter.—This type of a rapid mechanical filter consists of a steel filtering cylinder or drum surrounded by an outer cylinder leaving a space of five to six inches in width all round between the two. Raw water is first mixed with aluminium sulphate and allowed to remain in sedimentation tanks for one to six hours and then conveyed to the annular space closed at the bottom. From here it is led on the filter bed consisting of three to four feet of sand resting upon a thin bed of gravel. After water has filtered through the sand it is collected in a series of outlet pipes covered with perforated brass screens, and passes thence into a clean water reservoir through a controller which maintains the uniformity of the rate of output.

When the filter is to be cleansed, the inlet and outlet valves are closed and the wash out valve is opened. Filtered water is then admitted under sufficient pressure from below and percolates upwards through the filtering medium of sand which is at the same time agitated by four rotary arms round a central shaft. Cleansing takes only four or five minutes and the amount of water required varies from two and a half to five per cent. of the quantity that filters during the run between two washings.

Bell Patent Filter.—This filter belongs to the type of pressure filters and consists of a closed cylinder containing the filtering medium of powdered quartz. It is constructed with a view to pass raw water direct from the pipes under a very high pressure varying from thirty to three hundred pounds per square inch. But practically the pressure hardly exceeds ten to twelve pounds per square inch. Raw water is first treated with aluminium sulphate in a mixing tank and the mixture is then led on the filter beds.

The filter bed is cleansed by reversing a current of water forced through the perforated strainers. Jets of water issuing from the perforated revolving metal rakes will also break up the quartz granules.

In this type of the filter the filtered water may be directly carried into the mains without taking it into the clean water reservoir.

Candy Filter.—This filter is mainly suitable for the purification of water highly impregnated with iron and lead, both in solution and in suspension. It is a pressure filter and consists of closed cylinders, about five feet high, containing a filtering medium composed of polarite (magnetic oxide of iron), or oxidium (a porous compound of iron oxide, silica, lime, magnesia, etc.) and sand. Raw water is first saturated with dissolved oxygen from the air and then passed through the filtering medium so that organic matter is oxidized and bacteria are removed.

Sterilization.—The sterilization of water on a large scale has not been introduced into India, but it has been practised for many years past in America, as well as in Western Europe. This is effected by (a) chlorination, (b) ozonization, and (c) ultra-violet rays.

(a) **Chlorination.**—This is the most efficient and economical method of sterilizing public water supplies and has been tried with success in Europe and America. It has recently been adopted in some large cities of India, e.g., Madras, Lucknow, etc.

Chlorination destroys pathogenic organisms present in water, but does not remove its turbidity or affect the chemical composition of its constituents. Hence the present tendency in municipal water works is to submit raw water first to the process of filtration for the removal of suspended impurities and then to treat it with chlorine for the destruction of disease germs.

The following are the chief forms in which chlorine can be administered to water for the purpose of sterilization :—

1. **Bleaching Powder (Chlorinated Lime).**—This is manufactured on a large scale by passing chlorine gas over slaked lime, and the reaction that takes place is represented by the equation—

$$Ca\,(OH)_2 + Cl_2 = Ca\,OCl_2 + H_2\,O$$

The compound thus formed is a pure oxychloride of calcium, and contains approximately 50 per cent. of chlorine. But the commercial article which is often known as " bleach " contains 35 to 37 per cent. of chlorine, and occurs as a whitish powder or in friable lumps. Its chemical composition is 4 $Ca\,O\,Cl_2$. 2 $Ca\,(OH)_2$. 5 $H_2\,O$., and is assumed to contain 68% of calcium hypochlorite, 20% of calcium hydroxide and 12% of water. Being an unstable compound it deteriorates soon especially in the tropics. It, however, does not do so if stored in air-tight tins, with 20% of quicklime.

Normally there is no free calcium chloride in dry bleaching powder, but in the presence of water or moisture it splits up into calcium chloride, calcium hypochlorite and water. Some of the hypochlorite in the presence of carbon dioxide and water evolves nascent oxygen, and the reactions are expressed in the following equations :—

(*a*) $2\,Ca\,O\,Cl_2 = Ca\,Cl_2 + Ca\,(O\,Cl)_2$

(*b*) $Ca\,(O\,Cl)_2 + CO_2 + H_2O = Ca\,CO_3 + 2\,HClO$

(*c*) $2\,H\,Cl\,O = 2\,H\,Cl + O_2$

(*d*) $Ca\ Co_3 + 2\,H\,Cl = Ca\,Cl_2 + CO_2 + H_2\,O$

The evolution of the nascent oxygen does not fully explain all the details that take place in the action of bleaching powder on water. Free chlorine which is always available in the powder and which is also evolved when the hypochlorous acid decomposes acts as a germicide. Again chloramine (NH_2Cl) is produced when hypochlorite is brought into direct contact with ammonia or amino-acids. This is a

powerful germicidal agent, and explains to a certain extent the increased activity of hypochlorite in the presence of organic matter.

Owing to its powerful germicidal action chloramine was introduced for purifying water supply at Ottawa when the prices of bleaching powder had gone up very high during the last Great War. One of the chief advantages is that chloramine eliminates the problem of aftergrowths which are noted in the use of hypochlorite.

The amount of bleaching powder required to purify water varies from five to twelve or more pounds per million gallons of water, the actual quantity depending upon the presence of organic matter in water. If there is more organic matter in water, a larger quantity of the bleaching powder is required, as some of the bleaching powder is used to oxidize the organic matter before it can act on the bacteria.

In an installation where bleaching powder is used for the purification of water on a large scale the powder is dissolved and mixed with water in a mixing tank. The mixture is then allowed to flow into a storage tank, from where it is carried automatically to the main water supply so as to give the required concentration. When bleaching powder is treated with water, a large amount of calcium hydroxide contained in it being an insoluble salt falls to the bottom as a precipitate and forms what is known as "sludge". Hence there should be a provision for removing this sludge from the mixing tank from time to time.

In India bleaching powder is largely used for sterilizing the water of a well, tank, canal or river, especially when cholera is raging in the rural area. For sterilizing a well the bleaching powder is dissolved in a bucket of water and poured into the well, the water in the well being afterwards agitated by letting down the bucket to the bottom and pulling it up to the surface a number of times so that the chlorine may be diffused throughout the depth of the water.

In the case of a tank, canal or river the water nearest the front bank for a distance of nine or ten feet outwards should be purified, attention being particularly paid to the vicinity of bathing *ghats*, from which people take water for their domestic uses. Dr. Bentley[1], Director of Public Health, Bengal, recommends that 2 ounces of bleaching powder (25% strength) should be used for every ten feet of a pond or the bank of a canal or river. A larger amount should proportionately be used if the strength of the bleaching powder is less than 25 per cent. He recommends the following methods for purifying a tank or river water :—

1. Several pounds of bleaching powder enclosed in a cotton bag attached to the end of a long bamboo should be passed backwards and forwards through the water along and near the edges of the tank or river.

2. Dissolve 2 ounces of bleaching powder in a large watering can of water and distribute it over the surface of the water for a distance of ten feet along the bank and repeat the process until the whole tank has been treated.

About ten pounds of bleaching powder (25% strength) will thus be required for sterilizing all the water for a distance of ten feet from the edge of a tank having a mean depth of five feet and having an acre in extent. A round tank, an acre in size, will require 20% less, and a rectangular tank of the same size but with sides of unequal length will need 20% more.

2. **Electrolytic Hypochlorites.**—These are formed by electrolysis of water containing definite proportions of sodium and magnesium salt. The percentage of available chlorine depends upon the concentration of salt and other factors.

Electrolytic chlorogen is recommended for sterilization of wells and water supplies, especially during the cholera season. It will produce sterile water at dilutions of 1 in 40,000.

1. Anticholera Work for Government of Bengal, 1926, pp. 9-11.

According to Hutchinson[1] about 100 gallons will be required to sterilize a tank measuring 40 yards by 100 yards by 9 feet average depth.

3. **Liquid Chlorine.**—The use of liquefied chlorine for the sterilization of water supplies was first suggested by Lieutenant Nessfield, I.M.S., in 1903, but his suggestion was put into practical form by Major Darnall, of the United States Army Medical Corps, in 1910. Since then various improvements have been effected on the mechanism for regulating, measuring and applying chlorine with precision to water supplies. The Paterson Engineering Company have devised an apparatus known as "Chloronome" for this purpose.

Chlorine gas is formed on a large scale by the electrolytic decomposition of salt solutions. The moist gas generating from the electrolytic cells is dried, compressed into a liquid and stored in steel cylinders, each holding about 70 to 100 pounds.

One part of chlorine in one million of water is usually sufficient to sterilize water successfully in about thirty minutes, if it is fairly free from suspended matter of organic nature, but the chief factors to determine the amount of chlorine required for the sterilization of water are the quantity of oxidizable matter present, the temperature of the water, the method of application, and the period of contact. It has been estimated by the Paterson Engineering Company that 2.5 pounds of chlorine gas are sufficient to purify one million gallons of water.

The action of chlorine gas on water is similar to that of bleaching powder, but owing to the advantages in the use of chlorine gas it is rapidly replacing the bleaching powder. Chlorine gas can be obtained in a pure state, and can be stored indefinitely without deterioration and can be conveniently handled owing to the compactness of the apparatus. The dose can be regulated with a greater precision

1. Ind. Med. Gaz., October, 1922, pp. 365 and 366.

and the cost of labour is reduced to a minimum, as the chlorine apparatus does not need any special attention of expert chemists as in a bleaching powder installation, and there is no sludge which requires to be removed or pipes to be cleaned.

The complaint of the public is that this process of sterilizing water imparts a sharp pungent odour, and acid taste, which are especially noticeable in hot water. These render it offensive to the nose and palate, but this difficulty can be obviated by treating the chlorinated water with a small quantity of sodium thiosulphate or straining it through filters containing vegetable charcoal. The offensive odour and taste of chlorine will also disappear if the underground clean water reservoirs are furnished with floating ventilators, three-eighths of an inch above the surface of the water so as to carry away the residual chlorine gas.

Chlorine gas has recently been introduced for disinfecting swimming baths so that the same water may be used for as many as twelve months.[1]

(b) **Ozonization.**—As a sterilizer for large public water-supplies ozone has been used successfully in some continental towns, though the method is expensive. It oxidises the organic matter, and destroys the water bacteria, as also the pathogenic micro-organisms, except a few resisting spores, but these are harmless when swallowed with the water. It, however, does not clarify the water and has practically no action on the mineral salts. It is, therefore, necessary to treat the water first with alum and then to submit it to rough filtration, so as to eliminate all suspended matter, before ozone is applied.

For the purification of water ozone is prepared in a chamber by the silent electric discharge, and is then conveyed to the bottom of a sterilizing tower, a tall iron cylinder, about 25 feet high and about 3 feet wide, where in its upward

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1. Journal of State Medicine, June 1925, p. 294.

passage it is mixed with the descending water. One to three milligrammes of ozone are necessary for the purification of one litre of water.

(c) **Ultra-Violet Rays.**—The ultra-violet rays which have the power of destroying the water bacteria without producing chemical changes have been recently introduced for the sterilization of water on a large scale in Marseilles and other towns on the continent and in the United States of America. These rays are obtained from a mercury vapour electric lamp, known as the Westinghouse-Cooper-Hewitt mercury lamp. Water to be sterilized is allowed to flow slowly past the lamp enclosed in a tube made of fused rock crystal or quartz, so that it may be directly exposed to the action of the rays which are capable of passing through the rock crystal and quartz.

The ultra-violet rays exert their action only when water is fairly clear and bright, as turbidity or the presence of colloidal matter greatly retards the sterilization of water. It is, therefore, necessary to subject water to roughing filters to free it of its turbidity and suspended impurities before it is exposed to the direct action of these rays It has been estimated by Miguel that the ultra-violet rays destroy coli bacilli in clear and bright water in 15 to 20 seconds, typhoid bacilli in 10 to 20 seconds and the resisting spores from 30 to 60 seconds.

Distribution of Water.—In those cities where water-works are erected, water is either taken first from rivers as at Agra, or from canals as at Meerut, or from wells dug in the beds of rivers, as at Ahmedabad and Surat, or from tanks as at Ajmer, or from artificial lakes as from the Vihar, Tulsi and Tansa lakes of Bombay. From whatever source the water is derived, it is first purified by filtration through filtering beds.

Water, after having passed through this filtering tank, is collected in a third receptacle known as a storage reservoir

constructed ordinarily below the ground-level. From this storage reservoir, water is eventually distributed to the city by means of closed conduits or pipes. The pressure required for its distribution is usually supplied by force of gravity; but where water has to be supplied to localities situated on a higher level than the reservoir, preliminary pumping becomes necessary to supplement the mechanical force ordinarily sufficient. The storage reservoir should be so constructed as to have a capacity that will hold a water-supply for at least 8 days. It should, however, be cleaned every 3 months. At some places a garden is made on the roof of the reservoir. This is very harmful, if the roof is not impervious, for water is then liable to be contaminated with the manure used for the garden. Ventilators are provided for aeration of the water. They should be placed 3 or 4 feet above the ground so as to prevent anything from falling into the reservoir.

In large cities it becomes necessary to erect overhead supplementary or service reservoirs at various places to facilitate the distribution of water in certain areas. These are made of such a size as to hold at least 8 hours' average supply of water.

The pipes which convey water from the storage reservoir to streets are called mains and are constructed of cast iron. These should never be less than 3 inches in diameter, and should have on the inside a coating of Angus Smith's varnish consisting of coal tar pitch, resin and linseed oil, or a glassy lining to prevent rusting. They should be laid at least 3 feet deep from the surface of the ground, so that they may not be affected by traffic, heat and frost. From the mains in the streets, water is supplied to houses by small pipes called supply pipes or service pipes, which are made of lead, wrought iron, or galvanized iron. If possible, lead pipes should not be used, as soft water acts on lead, an oxide being formed which dissolves in water and acts as poison. Lead being a cumulative poison the continuous use

of water containing even 1/20 gr. of lead per gallon may lead to plumbism. This plumbo-solvent action of soft water is very much increased, if the water is acid, as in peaty water due to the formation of humic acid. But it is prevented by the presence of half a grain of silica and two grains of slaked lime or sodium carbonate per gallon. The advantage of the lead pipes lies in the ease with which they are bent. The service pipes are connected to the main by a brass screwed ferrule, and are controlled in the house by stop-cocks.

The joints of mains and service pipes should be made perfect so that there should be no leakage. They should not be laid near sewers, drains, or gas pipes lest they may be contaminated.

Stand posts are generally erected in the streets for the convenience of poor people who cannot afford to have house connections. These stand posts should have taps of such a kind as to allow a minimum of water. Self-closing taps are better. Taylor's taps are so made as to allow 3 to 5 gallons of water to come at a time by turning the handle.

In some cities, where it is difficult to obtain enough supply of pure water, a double supply—one of filtered water and the other of unfiltered water—has been in vogue. But this system of a double supply is not very safe, as mistakes are liable to occur in joining the pipes of filtered water with those of unfiltered water ; however, there can be no objection, if the supply of unfiltered water is only limited to trade purposes, to watering of parks and gardens, and to street cleansing.

Water-supply may be constant, *i.e.*, water may be obtainable from supply pipes at all hours during the day and night ; or intermittent, as in many big cities, when water is obtainable only for a few hours during the day. In constant supply there is no need to store water and thus no fear of water pollution by filth, dust, etc., but there is always a considerable wastage which can, however, be regulated by Deacon's water-meters attached to mains. These meters

register the flow of water by day and night, and hence by examining them at midnight the loss in water head may be noted. The wastage in houses can then be determined by visiting the houses when the vibrations produced by the leakage of water can be heard by means of a stethoscope applied to the service pipe.

In the intermittent system the pipes become corroded being empty for a greater portion of time, and are liable to be contaminated by foul gases and sewage impurities. Water has to be stored, and thus is liable to be contaminated while, in the case of an outbreak of fire, water is not immediately available.

Domestic Purification.—In those cities and towns, where water-works cannot be constructed owing to their cost, or any other reason, it is necessary that water should be purified in the houses of the people before it is used by them. Water may be purified by means of (1) distillation, (2) boiling, (3) filters, and (4) chemicals.

1. **Distillation.**—In distillation the vapour is condensed into a liquid by means of a continuous cold application. Its object is generally to free water from its impurities. This method is used in chemical laboratories, on boardships, and at places like Aden where fresh water is difficult to obtain ; but distilled water being flat and insipid owing to loss of dissolved gases and presence of scorched organic matter requires to be aerated before use. It also acts readily on metals, such as zinc, copper, lead and iron.

2. **Boiling.**—This is a very good method of purifying water. It removes solid matters, such as chalk, obnoxious gases, and organic matter, and kills disease-producing micro-organisms, such as those of cholera and enteric fever, but it has no effect on lead and other stable compounds contained in water or on immature spores which are ordinarily harmless. Boiling involves a large expenditure of fuel and leaves water too hot to be used at once. To

obviate these difficulties various portable apparatuses have been designed for boiling drinking water on the principle of heat exchange, so that the incoming stream of cold water receives all its heat from the outgoing stream of heated water from which it is separated only by a thin plate of iron. In this way water is boiled with the minimum of fuel and the boiled water issuing from the apparatus is almost as cold as that originally supplied. The chief of these apparatuses are the Forbes-Waterhouse Sterilizer and the Griffiths Water Sterilizer, which are, nowadays, supplied for the use of armies in manœuvres or in action. The Griffiths Water Sterilizer is capable of yielding 350 gallons of sterilized water per hour.

Boiling is very often resorted to by the Jain community in India, but they generally allow boiled water to cool in big open saucers where it is liable to be contaminated by dust, gases, etc. Water should, therefore, be kept boiling for a few minutes, and must be allowed to cool in covered vessels. Boiled water being flat and tasteless owing to the escape of dissolved gases should be aerated before use. Another method of purifying water prevalent in most parts of India is to put a red hot piece of iron, silver, or brick in an earthen pitcher of water. Water purified in this manner is given to patients.

3. **Filters.**—An ordinary method of filtering water in India is by straining it through a muslin cloth, but this is most objectionable, as it cannot prevent bacteria, foul gases and finely divided solid particles from passing through its fabric ; besides such a cloth is not usually kept clean, and is discarded only when it becomes very dirty or totally impervious. Efficient filters are ordinarily constructed with materials, such as charcoal, sand, silicated carbon, porous iron, etc. Besides, whatever materials are used, they should not only be sufficient in quantity, of a durable consistency, and capable of retaining impurities and germs for a reasonable period, but also their construction should be so arranged as to allow easy inspection or renewal.

Charcoal is very much used as a filter. Its particles should be well pressed together, so as to delay the passage of water; and the compressed layer must have sufficient depth to purify it thoroughly. It is, however, not the best filtering medium, because it absorbs impurities from the water or air, and becomes a source of danger unless it is often cleaned with boiling water, and renewed. It also adds to water nitrogen and phosphates, which form a nidus for micro-organisms to grow and develop, especially if it happens to be animal bone charcoal.

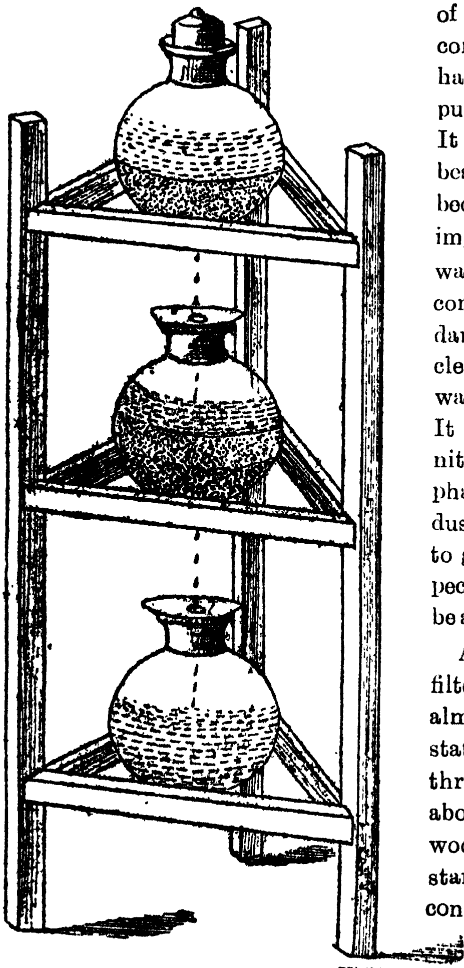

Fig. 5—Filtration of Water by Three-Ghara System.

A common variety of filter, which is seen at almost every railway station in India, is three *gharas* placed one above the other on a wooden or bamboo stand. The top *ghara*, containing sand, is filled with water, which percolates—through a hole made at its bottom along a piece of cloth or cotton introduced into the hole—into the second

ghara which contains a mixture of sand and vegetable charcoal. Water passing through the layers of sand and charcoal percolates through a hole at its bottom into the third and lowest *ghara* which will now contain filtered water. It is very difficult to look after the cleanliness of the contents of these *gharas* in private houses ; hence this system of *ghara* filtration must be condemned, and should never be used.

The best domestic filters which are capable of removing bacteria from water are those made of porcelain and clay, and moulded into candles or bougies. The candles are enclosed in metal cylinders by means of which they can be screwed on to ordinary water taps. In these filters water is forced through either by its own pressure in the main or by the use of a force pump. The main types of these filters are the Pasteur-Chamberland, the Berkefeld and the Porcelaine D'Amiante.

The Pasteur-Chamberland filter is made of fine glazed porcelaine (kaoline), and requires a good head of water even for a very moderate delivery of filtered water. Dr. Woodhead and Cartwright Wood found that without any pressure it required seven days to pass a pint of water. The filter holds back all kinds of bacteria and suspended matters present in water, but does not affect the chemical composition of the constituents dissolved in water, as its action is merely mechanical.

The Berkefeld filter is composed of compressed infusorial earth called *kiesselgurh.* It is similar in design to the Pasteur-Chamberland filter, but it is more porous and fragile. It is also more rapid in its action. With a pressure of 22½ pounds per square inch or a head of 50 feet it is capable of yielding two pints of filtered water in a minute.

The Porcelaine D'Amiante filter is composed of clay mixed with finely powdered asbestos. It is the most reliable for arresting disease organisms, but, is not suitable for domestic purposes owing to its slow filtering action.

While using these filters the householder should remember that the pores of the filtering medium are apt to

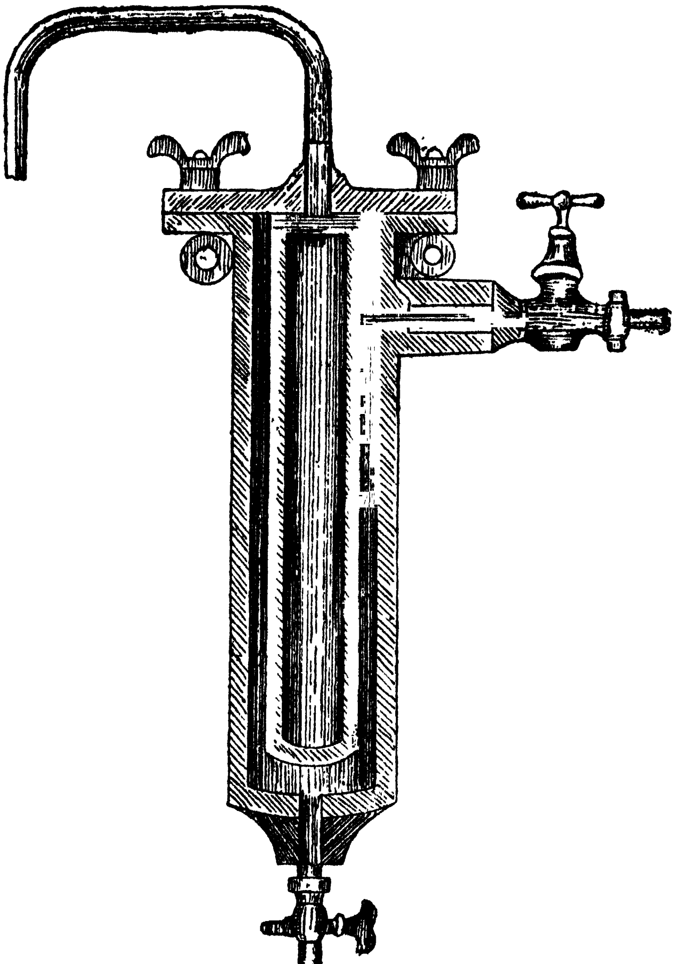

Fig. 6—Berkefeld Filter.

be gradually clogged with slime rich in bacteria which will reduce the rate of the flow of filtered water. But a more

serious danger is that the arrested pathogenic micro-organisms may soon grow through the walls of the filtering medium, and find their way into the filtered water. From experiments[1] conducted at Netley in 1901 Sir William Horrocks showed that typhoid bacilli were practically unable to pass through the finest and closest porcelain of Pasteur-Chamberland filter, but could grow through the large lacunar spaces of the infusorial earth of Berkefeld filter from four to eleven days. It is, therefore, very necessary carefully to cleanse these filters by scrubbing the outer surfaces of their candles with a brush and to boil or sterilize them by heat every third or fourth day.

4. **Chemicals.**—The chemicals that are used in purifying water are (1) Alum, (2) Nirmali **(Strychnos Potatorum),** (3) Copper sulphate, (4) Calcium oxide, (5) Chlorine, (6) Bromine, (7) Iodine, (8) Nesfield's tabloids, (9) Sodium bisulphate, (10) Potassium permanganate.

(1) Alum, when added to water containing calcium carbonate which is found in nearly all waters, is decomposed and insoluble calcium sulphate and alumina hydrate are precipitated carrying with them suspended impurities and bacteria as well, and leaving the purified water quite clear. This method is used to purify the muddy waters of rivers in China, and is used in water-works on a large scale in India. The quantity of alum will vary with the turbidity and the amount of calcium carbonate contained in the water. One to four grains are usually sufficient to add to each gallon of water. Instead of alum a double alumina-ferrous compound (a mixture of alumina sulphate and ferrous sulphate) is used. One and-a-half grains of this salt are enough for one gallon of water, but it has the disadvantage of imparting permanent hardness to water.

(2) Nirmali (the fruit of Stryehnos Potatorum) is usually rubbed with a little water on a stone slab, and the

1. Brit. Med. Jour., Vol. 1, 1901, p. 1471.

resulting paste is dissolved into water, stirring it up thoroughly within the receptacle. After a few minutes all the mud settles to the bottom. Thirty grains on the average are required for treating a hundred gallons of water. This is, however, not a safe method.

(3) Copper sulphate in the proportion of 0.1 to 0.25 per 1,000,000 parts of water prevents the growth of algæ and other vegetable micro-organisms which give rise to bad odours and unpleasant tastes to stagnant water. In the proportion of 1 part to 100,000 parts of water it is reputed to destroy typhoid and other pathogenic germs, probably within twenty-four hours. Copper chloride is considered to be more efficacious. It is also true that strips of copper foil immersed in water for twelve hours will destroy typhoid germs. Probably it is owing to this germicidal action of copper that Hindus use copper vessels for storing water.

(4) Calcium oxide or quicklime has long been used as a sterilizer of water showing fæcal contamination. Houston recommends the use of calcium hydroxide or slaked lime instead of lime. According to him 67 grains of slaked lime will sterilize ten gallons of soft water within twelve hours. In the case of hard water most of the lime will be used up in precipitating carbonates from bicarbonates, hence 180 grains of slaked lime are required to sterilize such water in eight to twelve hours. The quantity of slaked lime for sterilizing water is proportionately reduced if the contact of the salt with the water is allowed a longer time.

Quicklime being cheap and easily procurable is highly recommended for disinfecting the water of a well or tank at the time of an outbreak of cholera in villages. An ounce of quicklime is ordinarily allowed for every foot of the bank. This amount generally sterilizes all the water within 10 feet of the bank of the tank within 24 hours. Quicklime is kept in a gunny bag and pushed or drawn through the water by means of a rope or bamboo. About 56 pounds will be required

for treating a tank, an acre in extent. By this method cholera germs are killed in water in 3 or 4 days in dry weather and in 7 or 8 days during the monsoon.[1]

(5) Chlorine gas is produced by the action of hydrochloric acid on potassium chlorate, and is then added to water in the strength of 1 in 2 millions, which is said to kill all disease-producing germs of water. This is a very cheap and convenient method of purification of water, and was used on a large scale during the last Great War. As already mentioned it is now used for sterilizing filtered water in municipal water works.

A simple test for efficient chlroination is to drop a crystal of potassium iodide and a few drops of a freshly prepared solution of pure starch into a tumbler of sterilized water after half an hour of chlorination, when a bluish green colouration develops indicating that the treatment of water with chlorine has been effective.

Instead of chlorine gas bleaching powder or hypochlorite of lime may be used in the proportion of 1 05 grains per 10 gallons of water. It is now-a-days used for disinfecting wells for which two to six ounces are sufficient according to the quantity of water. The ordinary test is that a sufficient quantity should be added to make the water taste brackish. A solution of sodium hypochlorite, known as "chloros" and containing 10 to 15 per cent. of available chlorine is also recommended in the proportion of 0.00664 ounce per 10 gallons of water. It was first used successfully by Houston at Lincoln in 1905 to purify the water supply which became infected with typhoid germs.

If the sterilized water after it is treated with chlorine or any other compound containing chlorine is allowed to stand for twenty-four hours, there will, usually, be no odour or taste of chlorine in the water. On the other hand, if any odour or taste is left in the water, sodium thiosulphate

1. Bentley, Anticholera Work for Govt. of Bengal, 1926.

should be added as an " anti-chlor ". Ordinarily 1.225 grains of this salt are sufficient to remove the bad effects produced by the addition of chlorine (0.5 per million) to water. It should, however, be remembered that sodium thiosulphate should be added only after chlorine had had its sterilizing action on water.

A new chemical compound of chlorine,[1] p-sulphondichloraminobenzoic acid, is recommended by Dakin and Dunham for sterilizing small individual quantities of drinking water. For convenience they give the name of " Halazone " to this new substance. It can be put up in tabloids and one or two tabloids are sufficient to sterilize a quart of water in thirty minutes.

(6) 0.06 grain of bromine dissolved in potassium bromide and added to a litre of water kills bacteria in five minutes. The offensive smell of bromine may be removed by further treating the water with sodium sulphite and sodium carbonate. This method was first proposed by Schumberg.

(7) Vaillard uses iodine to destroy micro-organisms present in water. He employs three tablets, *viz.*, blue, red and white. The blue tablet contains 0.1 gramme of potassium iodide, 0.016 gramme of sodium iodate and methylene blue. The red tablet contains 0.1 gramme of tartaric acid and fuchsin. The white tablet contains 0.12 gramme of sodium hyposulphate. One blue and one red tablet are added to a litre of water, when free iodine is liberated. It destroys typhoid and cholera germs in 5 to 10 minutes. After 15 minutes one white tablet is added which neutralizes the free iodine by forming iodide of sodium and renders water fit to drink.

(8) Nesfield's Tablets.—Nesfield claims that a two grain tablet of iodide-iodate of sodium and the same quantity of citric acid added to four gallons of water will kill cholera and typhoid germs in a few minutes. The free iodine present

1. Brit. Med. Jour., Aug. 11, 1917, p. 184.

in water may then be removed by adding a tablet of sodium hyposulphite.

(9) Sodium bisulphate in the proportion of 15 grains to one pint of water has been used by Rideal and Parkes. It kills disease germs, such as those of cholera, typhoid and dysentery in half an hour, but it imparts a somewhat acid taste to the water. To obviate this difficulty Notter and Firth recommend the use of a tabloid containing 2 grammes of 70 per cent. sodium bisulphate sweetened with saccharine and flavoured with oil of lemon. One tabloid is sufficient to sterilize thirty-five ounces of water in twenty minutes.

(10) Potassium permanganate oxidizes all organic matter, and also serves as a deodorant. Clark and Gage conducted some experiments regarding its germicidal action, and proved that 0.5 part of the salt added to 100,000 parts of water was sufficient to destroy over 98 per cent. of bacteria in from four to six hours. In India Hankin was the first to recommend its use for disinfecting cholera-infected wells. Hence the process of disinfecting wells with potassium permanganate is known as "Hankinisation". It is now largely used for disinfecting wells. The disinfection is done by dissolving one ounce of potassium permanganate in a bucket (*dol*) full of water. The water is then poured into the well and down its sides, and the process is repeated until all the crystals in the bucket are dissolved. The water, when thus treated, has a faint pink colour, which, if retained after four hours, is taken as an evidence of satisfactory disinfection. If, on the other hand, the colour be light-brown instead of pink, it should be taken as an indication that further treatment with the salt is necessary. Again, if a bad smell appears in the water two or three days after adding it to a well the treatment with permanganate should be repeated. Condy's fluid is a solution of sodium permanganate, and is equally efficacious with potassium permanganate. Sodium permanganate does not crystallise well. Hence it does not occur in commerce in the dry form.

COLLECTION OF SAMPLES OF WATER FOR ANALYSIS.

Clean and sterilized stoppered bottles of about 100-200 c.c. capacity should be used for taking specimens of water.

The bottle should preferably be sterilized by dry heat. At times when this is not possible, the bottle may be rinsed out after well cleaning, with a little strong sulphuric acid, and then rinsed well several times with the water to be examined before the specimen is taken.

In collecting water from a standpost, let the water run for five minutes, and wash the tap before taking the sample. When taking out the stopper of the bottle take care that the fingers do not touch either the mouth of the bottle or the part of the stopper that goes into the mouth of the bottle.

If water has to be collected from a water reservoir, since the surface layers are likely to be contaminated from the air, it is advisable to take the specimen of water from a point some way beneath the surface. In the case of a river or pond too the same precaution should be adopted in collecting the specimen. The bottle should be immersed about twelve inches below the surface and away from the edge before the stopper is removed, but care should be taken that the river bed is not touched, as many organisms are contained in the vegetable matter covering it. It should be filled and corked under the surface of water, care being taken to allow some air space in the bottle.

If water has to be taken from a well, the bottle made by Dr. Thresh should be used. It has got a contrivance by which water can be made to enter at any required depth below its surface.

The bottle should not be exposed to light, but should be kept in a cool place, and after packing it in sawdust and ice should be sent for analysis as soon as possible without any delay. A double chambered metallic box, the inner chamber of which is to hold the bottle containing the sample, and the

outer, the sawdust and ice, the whole being packed in a felt-lined wooden box, will, as used by some workers, be found suitable. Full particulars should be described on the label as follows :—

(1) Source of water, whether from a reservoir, tank, pond, lake, river, well or water pipe; (2) approximate depth in the case of a well; (3) position of the source and nature of the soil in which the source is situated; (4) whether there are any cultivated fields, stables, cesspools, drains, latrines, etc., in the vicinity; (5) if any infectious diseases have been raging in the vicinity; (6) meteorological conditions; and (7) nature of analysis required. Lastly, each bottle should be labelled with a number corresponding to the number of the official letter for purposes of identification.

ANALYSIS OF WATER.

The examination of water is most commonly carried out to determine the presence or absence of evidence of sewage contamination. No one is likely to use for domestic purposes water that is turbid or muddy, or which has a disagreeable taste and unpleasant smell. Yet a water may be quite clear, bright, sparkling and sweet in taste, and still may be highly dangerous for domestic use. Hence it is necessary that a thorough examination should be carried out by specially trained chemists and bacteriologists, before the water is used by a community.

The examination of water consists of—

1. Physical examination.
2. Chemical examination.
3. Microscopical examination.
4. Bacteriological examination.

PHYSICAL EXAMINATION.

This is conducted by the senses, and includes the following points :—

(*a*) **Taste.**—Hard waters have a brisk saline taste. Iron, existent in quantity to 1/5 grain per gallon, imparts its chalybeate taste. Lime salts impart their taste, when present in quantities of 10 to 25 grains per gallon. The taste of sodium chloride is not detected, unless present to 75 grains per gallon, and sodium carbonate to 60 grains.

(*b*) **Odour.**—This is detected by adding a few drops of caustic potash, or by gently warming the water in a corked flask, and then by smelling at once on removal of the stopper. A disagreeable smell of hydrogen

sulphide, particularly noticeable in hot weather, is given off by polluted water in which organic substances are undergoing a process of decomposition. An offensive smell observed on drawing water from a well shows that there is stagnation at the bottom, or a dead body is lying in the water, a not infrequent occurrence in Northern India, where bodies after murder are thrown into wells or tanks to conceal crime.

(*c*) **Colour.**—This is determined by looking through a column of water contained in a 2-foot tube with a ground glass bottom held against a white surface. The colour should always be compared with that of the distilled water. A greenish blue colour is observed in pure water. A yellow colour may be due to decaying vegetable or animal matters, especially of sewage contamination. A grey colouration observed in certain rivers is generally due to fine mud held in suspension. A brown colour is usually imparted by peaty water, while a reddish brown colour indicates the presence of iron.

(*d*) **Aeration.**—This is determined by noticing the liberation of gas bubbles on shaking a portion of water in a glass bottle. Carbonic acid makes water sparkling and refreshing, and has the power of dissolving certain earthy substances, *e.g.*, salts of calcium, magnesium and iron.

CHEMICAL EXAMINATION.

1. **Reaction.**—The reaction of water is usually neutral. Sewage contaminated waters are generally alkaline. Waters polluted by refuse from chemical or dye works are sometimes acid in reaction. Upland surface water is frequently acid owing to the formation of humic and ulmic acids which dissolve lead.

2. **Total Solids.**—To find the total solids dissolved in a sample of water, evaporate to dryness 20 c.c. of the water in a weighed platinum or porcelain dish, allow it to cool in a desiccator and weigh it. The number of milligrammes of residue multiplied by five represents the number of total solids per 100,000. If the residue is incinerated at as low heat as possible, it chars and gives off an odour. If heat is still continued, the black colour of charring is changed to white showing that all the volatile organic matter has been incinerated. The dish is then allowed to cool, and is again weighed. The loss in weight corresponds to the volatile solids present in 20 c.c. of water, which consist of the organic matter, nitrates, nitrites, salts of ammonia, combined carbonic acid and sometimes chlorides, while the remaining weight is that of the total fixed mineral solids.

3. **Chlorine.**—To ascertain the presence of chlorine as chloride, the sample of water must be colourless and neutral. If acid, it should be neutralized by the addition of sodium carbonate before estimation is made as silver chloride is soluble in acid. It is estimated by placing 100 c.c. ot the water in a clean porcelain basin and adding a few drops of a 5 per cent. solution of potassium chromate, which gives the liquid a yellow tinge. A standard solution of silver nitrate contained in a burette is then allowed to run in drop by drop while stirring, until a reddish colour persists. The silver nitrate solution is made by dissolving 4.797 grammes of silver nitrate in 1 litre of water, so that 1 c.c. is equal to 1 milligramme of chlorine or 5.8 milligrammes of silver chloride. Chlorine in the form of sodium chloride is normally present in waters, either derived from certain geological formations of the soil, manufactories and mines, or from sewage contamination. It is, therefore, necessary to take into consideration these possible sources before interpreting the presence of chlorides in a particular water. Two to three grains of sodium chloride are generally present in a gallon of water. According to Wanklyn water which contains five to ten grains of sodium chloride per gallon should be considered suspicious. According to Dr. Thresh water should be considered objectionable if it contains fifty grains of sodium chloride per gallon, and should be condemned if it contains seventy grains per gallon.

4. **Hardness.**—The amount of hardness present in water is usually expressed in degrees. Each degree corresponds to one grain of calcium carbonate or its equivalent of other calcium or magnesium salts in a gallon of water. It is determined by Clarke's soap method, which is carried out in the following manner :—

A solution of soap is made by dissolving 10 grammes of finely powdered Castile soap in a litre of 35 per cent. of alcohol. It is standardized with a solution of lime, made by dissolving 1.11 grammes of pure calcium chloride in a litre of distilled water, so that 1 c.c. is equivalent to 1 milligramme of calcium carbonate or an equivalent salt, *i.e.*, 1 grain to a gallon. 100 c.c. of the water are taken in a bottle, to which the standard soap solution from a burette is added in small quantities at a time, shaking the bottle briskly after each addition, until a lather is formed, which persists for 5 minutes, after the bottle is laid on its side. The number of cubic centimetres of the soap solution used corresponds to the number of grains of lime per gallon or to the degrees of total hardness. One c.c. must always be subtracted, as 100 c.c. of distilled water require 1 c.c. of soap solution, before it forms a lather.

To estimate permanent or fixed hardness half a litre of the water is boiled until it is reduced to half its volume, and distilled water is added

to make up its original volume. It is then tested with the standard soap solution. The temporary or removable hardness is the difference between the total and the premanent hardness.

The total hardness should not exceed 30 parts per 100,000 in a water used for domestic purposes, while a soft water contains from 8 to 15 parts.

5. **Organic Matter.**—This is of vegetable and animal origin and exists both in solution and in suspension. Vegetable matter is harmless, unless it is in excessive amount, when it may produce diarrhœa. Animal matter is often associated with the presence of micro-organisms, and hence the danger of drinking water polluted with sewage lies in the possible danger of taking in pathogenic bacteria. Owing to its decomposition in water much of the organic matter passes off as nitrogen and carbonic acid, a large part is united to form ammonia and some of it at a later period, and under the action of nitrifying organisms, becomes changed into nitrites of calcium, sodium, potassium, etc., and still later these are oxidized into nitrates. The presence of these singly or combined indicates the degree of pollution, *e.g.*, ammonia shows present active contamination, nitrite that it has recently taken place, and nitrate that some little time has elapsed, and that the water has undergone a certain amount of self-purification. Ammonia and nitrates may, however, also result from the reducing action of lead or iron salts.

Wanklyn's Process of estimating Organic Matter.—There is no direct method by which the amount of organic matter present in a sample of water can be determined, but Wanklyn has devised a process by which the amounts of free and saline ammonia and albuminoid or fixed ammonia can be determined.

Free and Saline Ammonia.—The following chemical solutions are required for estimating the amount of free and saline ammonia in water :—

1. Nessler's Reagent.
2. Standard Solution of Ammonium Chloride.

1. **Nessler's Reagent.**—This consists of a saturated solution of biniodide of mercury, and rendered strongly alkaline with potassium or sodium hydroxide. It is prepared by dissolving separately 13 grammes of mercuric chloride in 250 c c. of water, and 35 grammes of potassium iodide in 250 c.c. of water. Both the materials are heated to boiling, and stirred up until the salts dissolve. The two solutions are then mixed slowly, when a red precipitate of biniodide of mercury appears at first, which is afterwards redissolved in the excess of potassium iodide. A cold saturated solution of mercuric chloride is then added drop

by drop, until a slight red precipitate remains permanent. The mixture is heated to the boiling point, when the precipitate will be mostly dissolved. The mixture is then cooled under a tap and decanted. A solution of potassium or sodium hydroxide is prepared by dissolving 120 grammes of the salt in 400 c.c. of boiling water. It is then cooled and added gradually to the cold biniodide solution of mercury to render it alkaline. The whole is finally made up in bulk to one litre with more water. This solution should be slightly yellow in colour. If not, a drop or two of mercuric chloride solution should be added. The reagent should be kept in a tight-fitting glass stoppered bottle. It gives a yellow precipitate to ammonia, but reddish brown, if in excess.

In preparing this reagent ammonia-free distilled water should be used.

2. **Standard Solution of Ammonium Chloride.**—This is prepared by dissolving 3.14 grammes of pure ammonium chloride in a litre of ammonia-free distilled water. 10 c.c. of this solution is again diluted to a litre of the ammonia free distilled water. One c.c. of the solution will then contain 0.01 milligramme of ammonia.

The apparatus used in the estimation of ammonia consists of a 1500 c.c. round-bottomed distilling flask, with a ground glass stopper, having a fused-in delivery tube, bent at right angles and fitted into a double surface condenser. A set of three or four Nessler cylinders, graduated to contain 50 c.c., and a white porcelain slab are also necessary.

In order to ensure that the apparatus is free from ammonia it is necessary first to distil some clean water through it, until the distillate gives no reaction with Nessler's reagent. 500 c.c. of the water to be analysed are added to the contents of the boiling flask, into which about a gramme of pure anhydrous sodium carbonate has been placed. The flask is then connected to a condenser in such a way that the distillate may be directly received into Nessler cylinders. Three cylinders should thus be filled up to 50 c.c. marks from the first portion of the distillate that comes over. To each of the three cylinders 2 c.c. of Nessler's reagent are slowly added, and by holding them against a white porcelain slab the yellow colour obtained in the cylinders will show a decrease in amount from left to right.

The amount of free ammonia in these three cylinders is determined by comparing the depth of colour with Nessler cylinders containing known quantities of the standard ammonium chloride solution in 50 c.c. of distilled water free from ammonia and to which 2 c.c. of Nessler's reagent are added. The total amount of the standard solution of ammonium chloride added to the test cylinders to match the colour of

the cylinders containing 50 c.c. distillates corresponds to the ammonia present in 500 c.c. of the sample water.

A sample of good water should not contain more than 0.05 of free ammonia per million; a larger quantity must be looked upon with suspicion. It should be noted that the free ammonia which comes off with the first part of the distillate seldom exists in water as dissolved ammonia, but as ammonium carbonate, nitrate or chloride. On boiling these are easily broken up into ammonia.

Albuminoid Ammonia.—Much organic matter may remain in the flask, after 150 c.c of water have been distilled over. To determine this it must be oxidized by a strongly alkaline solution of potassium permanganate, when nitrogen contained in the organic matter is converted into ammonia, called by Wanklyn as albuminoid ammonia. The alkaline potassium permanganate solution is prepared by dissolving 8 grammes of potassium permanganate and 200 grammes of caustic potash in a litre of ammonia-free distilled water. It is desirable to boil the solution for about ten minutes before use in order to ensure the expulsion of any traces of ammonia.

The estimation of albuminoid ammonia is performed upon the remaining portion of the water left in the distilling flask, after the determination of free and saline ammonia. After the contents in the flask have cooled, 50 c.c. of the alkaline solution of potassium permanganate are added, and distillation is continued until three portions of 50 c.c. each of the distillate have been collected in separate Nessler cylinders. The amount of ammonia in each is estimated by Nessler's reagent in the manner described under the heading of free and saline ammonia.

The presence of albuminoid ammonia in water shows its contamination with organic matter. The presence of much albuminoid ammonia with practically no free ammonia shows the contamination of water with vegetable matter, while a large quantity of free ammonia and practically little or no albuminoid ammonia indicates animal contamination. Waters from deep wells yield as a rule no albuminoid ammonia. Upland surface waters usually yield a small quantity of albuminoid ammonia varying from 0.005 to 0.015 part per 100,000. A larger quantity than this must be regarded as suspicious.

Estimation of Oxygen Absorbed.—Forchammer devised a method of estimating the organic matter from the amount of oxygen absorbed by it from a solution of potassium permanganate. Various methods for conducting the test have since been proposed, but Tidy's method is generally used at present. The reagents required are—

1. A standard solution of potassium permanganate made by dissolving 0.395 gramme of the pure salt in 1000 c.c. of distilled water. 1 c.c. of this solution is equal to 0.0001 gramme of available oxygen. The solution is not stable, and must be made up fresh at frequent intervals.

2. A dilute sulphuric acid solution made by adding 33 c.c. of pure concentrated sulphuric acid to 66 c.c. of distilled water. A solution of potassium permanganate is gradually added to it until a faint pink colour remains after four hours at a temperature of 80° F.

3. A solution of potassium iodide prepared by dissolving 10 grammes of potassium iodide in 1000 c.c. of distilled water.

4. A solution of starch made by rubbing up 1 gramme of pure potato starch with 200 c.c. of distilled water and boiling it for five minutes. It should be prepared fresh whenever required, as it goes mouldy by keeping.

5. A solution of sodium thiosulphate made by dissolving 1 gramme of the pure recrystallized salt in 1000 c.c. of distilled water.

For the determination of the oxygen absorbed two stoppered flasks or bottles of 500 c.c. are taken and are cleansed first with a small quantity of strong sulphuric acid and then with a large quantity of distilled water. Into one flask are poured 250 c.c. of the sample water and into the other the same amount of distilled water. 10 c.c. of the standard solution of potassium permanganate and 10 c.c. of the dilute sulphuric acid solution are added to both the flasks, which are then placed on a water bath at 80° F. At the end of four hours a few drops of the potassium iodide solution are added to each flask, when a yellow colour is obtained owing to the liberation of free iodine by the action of potassium iodide on the unreduced potassium permanganate. The solution is then titrated with the standard solution of sodium thiosulphate till the yellow colour has almost disappeared. A few drops of starch solution are added to produce a blue colour, and the sodium thiosulphate solution is further added till the blue colour has disappeared. The difference between the amount of sodium thiosulphate used for the distilled water and that used for the sample will give the amount of oxygen absorbed by the organic matter contained in 250 c.c. of the sample water.

Nitrites.—The presence of nitrites is shown by the following tests :—

1. The Starch Test.
2. Ilosvay's Naphthylamine Test.
3. Greiss's Metaphenylene-diamine Test.

1. **Starch Test.**—For ordinary purposes this is a reliable test for the detection of nitrites in water, provided there is no sulphuretted

hydrogen in it. It is performed by taking some of the water in a test-tube, and then adding a few drops of potassium iodide solution, a few drops of a clear starch solution and a drop of dilute sulphuric acid, when a blue colour appears immediately, which deepens on standing.

2. **Ilosvay's Naphthylamine Test.**—For the performance of this test the following solutions are necessary :—

(*a*) **Sulphanilic Acid Solution.**—This is prepared by dissolving 0.5 gramme of sulphanilic acid in 150 c.c. of dilute acetic acid having a specific gravity of 1.04.

(*b*) **Naphthylamine Solution.**—This is prepared by dissolving 0.1 gramme of a-naphthylamine in 20 c.c. of distilled water, filtering it through washed absorbent cotton, and adding 150 c.c. of dilute acetic acid.

The presence of nitrites is indicated by the formation of a pink colour, when 1 c.c. each of sulphanilic acid solution and naphthylamine solution is added to 50 c.c. of sample water in a Nessler cylinder.

The amount of nitrites is estimated by comparing the degree of the pink colour produced by this test with that produced by the addition of 1 c.c. each of the sulphanilic acid and naphthylamine solutions to 50 c.c. distilled water contained in Nessler cylinders and to which known quantities of a standard solution of potassium nitrite, varying from 0.25 to 2 c.c. have been added.

The standard solution of potassium nitrite is prepared by dissolving 0.406 gramme of pure silver nitrate in hot distilled water, and by adding a solution of pure potassium chloride till no further white precipitate of silver chloride is formed. The mixture is cooled and made upto 1000 c.c. After the precipitate of silver chloride has settled down at the bottom, 100 c.c. of the clear solution is pipetted off and diluted to 1000 c.c. 1 c.c. of this solution equals 0.00001 gramme of nitrite. This solution rapidly oxidises, and has therefore to be prepared fresh, whenever required.

3. **Greiss's Metaphenylene-diamine Test.**—The solutions required in this test are—

1. **Metaphenylene-diamine Solution.**—This is prepared by dissolving 2 grammes of metaphenylene-diamine hydrochloride in distilled water, and diluting it to 100 c.c.

2. **Sulphuric Acid Solution.**—This is prepared by diluting one volume of pure sulphuric acid with two volumes of water.

3. **Standard Solution of Potassium Nitrite.**—The method of preparing this solution has already been described above.

This test is performed by adding 1 c.c. of the metaphenylene-diamine solution and 1 c.c. of dilute sulphuric acid to 100 c.c. of the sample water, when a yellow colour is produced in the presence of nitrites. The amount of nitrites is determined by comparing the colour with that obtained by the addition of these reagents to the known quantities of the standard potassium nitrite solution in Nessler cylinders. The comparison should be made after the lapse of thirty minutes, as the colour is developed only progressively within about the same time.

Water containing nitrites shows recent contamination of organic matter, and is therefore not safe for domestic purposes. It should, however, be remembered that nitrates present in water might be reduced to nitrites when the water is stored in zinc, iron and lead cisterns, or when it passes through service pipes of these metals.

Nitrates.—There are several methods for estimating the presence of nitrates in water, but the following are the most commonly used :—

1. The Colourimetric Method.
2. The Diphenylamine Test.

1. **The Colourimetric Method.**—The solutions required in the performance of this test are—

(*a*) **Phenol Sulphuric Acid Solution.**—This is prepared by dissolving 6 grammes of pure phenol in 3 c.c. of distilled water and adding 37 c.c. of pure concentrated sulphuric acid. The mixture is then heated on a water bath at 82° C. for six to eight hours. It is afterwards cooled and preserved in a tightly stoppered bottle.

(*b*) **Standard Solution of Potassium Nitrate.**—This is prepared by dissolving 0.722 gramme of pure potassium nitrate in 1000 c.c. of distilled water, so that 1 c.c. of the solution contains 0.0001 gramme of nitrogen.

The process of this test depends upon the fact that, when acted upon by phenol-sulphuric acid, nitrates form a compound resembling picric acid, which has a yellow colour, rendered much deeper in the presence of excess of ammonia.

The test is performed by taking 10 c.c. of the sample water in a porcelain dish and evaporating it to dryness on the water bath. 3 c.c. of the phenol-sulphuric acid solution are added to the porcelain dish, and the contents are thoroughly mixed with a glass rod on the water bath. The dish is washed with 25 per cent. ammonia solution, and the washing is poured into the Nessler cylinder. More ammonia solution is further added

to make up the mixture to the 50 c.c. mark in the cylinder. If nitrates are present, the yellow colour will be produced. The amount can be determined by comparing the colour with the known quantity of the standard solution of potassium nitrate to which the same amount of the phenol-sulphuric acid solution has been added and which has gone through the same procedufe.

2. **The Diphenylamine Test.**—A few drops of an alcoholic solution of diphenylamine and one or two drops of dilute sulphuric acid will give a blue colour in the presence of nitrates. This is convenient for a qualitative test.

Nitrates are the ultimate results of the oxidation of animal organic matter by bacteria, and must be regarded as evidence of past or distant contamination. If a water contains an appreciable quantity of nitrates but no nitrites or ammonia, it shows that the nitrates are probably derived from the soil, where pollution occurred at some distant date. It is generally laid down that potable water should not contain more than 0.4 to 0.2 part of nitrates to 100,000 parts of water. But this cannot be laid down as a limit to a standard of purity, inasmuch as Dr. Thresh has found that 2 to 5 parts of nitrates per 100,000 parts of water without a trace of nitrites have been taken with impunity by people in some villages.

Mineral Constituents.—Under this heading are usually included lead, iron, zinc, copper, lime, magnesia, phosphates and sulphates.

Lead.—To detect the presence of lead, water is first acidified by acetic acid, and then hydrogen sulphide is added to it when a black precipitate is produced. The colour remains unchanged on the addition of dilute hydrochloric acid, but the chloride is thrown down, and dissolves on boiling the mixture. A solution of potassium chromate gives a yellow turbidity in the presence of lead. With 1/10 grain per gallon this turbidity is seen in half a minute on looking down at a dark surface. With larger amounts of the metal the turbidity appears more rapidly. The amount present may be estimated colourimetrically. Equal quantities, say, 100 c.c. of sample water and distilled water, are taken in Nessler cylinders to which 1 c.c. of potassium chromate is added. If lead be present, the sample water assumes a yellow turbidity. This colour must be matched in the other glass by adding a sufficient standard lead solution. Calculation will bring out parts per 100,000 or in any other proportion. The standard lead solution is made by dissolving 0.1831 grammes of lead acetate per litre of freshly distilled water, of which 1 c.c. corresponds to 0.1 milligramme of lead. Water containing the minutest quantity of lead must be condemned for domestic use.

Iron.—This is detected by ammonium sulphide giving a black precipitate to the water, which is dissolved by adding dilute hydrochloric acid. Its presence is then confirmed by adding potassium ferrocyanide, when a blue colouration is produced. Potassium sulphocyanide produces a blood-red colour after the ferrous salt contained in water is converted into the ferric state by adding nitric acid. The amount of iron is estimated by comparing the blood-red colour thus obtained with the colour produced in a distilled water by adding enough quantity of the standard iron solution after nitric acid and potassium sulphocyanide have been added to the same quantity of the distilled water. The standard solution is prepared by dissolving 4.96 grammes of ferrous sulphate in a litre of water, so that 1 c.c. is equivalent to 1 milligramme of iron.

Iron is perceptible to taste when present to the extent of 1/2 grain per gallon or 1 part in 350,000 parts of water. When present in water, it supports a fungus, which may grow in pipes in sufficient amount to obstruct the flow of water or even completely choke them.

Zinc.—Hydrochloric acid and potassium ferrocyanide added to water give a white turbidity, if zinc is present in water. The amount is estimated colourimetrically. It is often found in waters which have been stored, for some time, in galvanized vessels, or in those collected from zinc galvanized roofs.

Copper.—This is a rare constituent of natural water. It is detected by adding hydrochloric acid and potassium ferrocyanide to the water, when a reddish brown colour is produced. It is estimated quantitatively as for lead by using a standard solution of copper sulphate made by dissolving 3.95 grammes of the salt in 1 litre of distilled water, so that 1 c.c. contains 1 milligramme of copper.

Lime.—Ammonium oxalate gives a distinct turbidity with 8 parts of lime per 100,000 and a white precipitate with anything over 20 parts per 100,000.

Magnesia.—If ammonium chloride, ammonium hydrate and sodium phosphate are added to the water containing magnesia, the crystalline precipitate of ammonium-magnesium phosphate is formed after allowing it to stand for 24 hours. As lime and magnesia are often present together from strata, it is necessary first to precipitate, and filter any lime present, before the test for magnesia is applied.

Phosphates.—Strong nitric acid and ammonium molybdate give a yellow precipitate, if phosphates are present.

Sulphates.—These are found in hard waters in combination with lime and magnesia. Their presence is indicated by adding dilute

hydrochloric acid and barium chloride when a heavy white precipi. tate is obtained, which is insoluble in all acids.

Sulphides.—These are detected by adding a solution of lead acetate to the water, when a black precipitate of lead sulphide is obtained. If caustic soda be added to equal quantities of water and nitro-prusside of sodium solution, a violet colour is produced. This is a delicate test for detecting minute quantities.

MICROSCOPICAL EXAMINATION.

The object of the microscopical examination of water is to determine the nature of the suspended matters and thereby the source of the water.

Suspended matters may be found by holding a clear glass vessel containing water against good light. To ascertain their nature water should be allowed to stand in a conical glass for an hour or two, and a few c.c. should be pipetted off from the bottom, centrifuged and examined carefully with a microscope by preparing several slides with the deposit.

The suspended matter may consist of—

1. Minereal matter, *viz.*, sand, clay, chalk, oxide of iron, etc.

2. Vegetable matter, *viz.*, (a) *living*, e.g., yeasts, moulds, diatoms, desmids; and (b) *dead*, *e. g.*, vegetable cells, cotton, linen or flax fibres, husks of grain, starch grains, and fragments of food as a result of waste products of man.

3. Animal matter, *viz.*, (a) *living*, such as worms, insects and their ova; and (b) *dead*, such as debris of insects, wool, hair, epithelial scales, muscle fibres, shreds of membrane, epithelial cells, etc., indicating sewage contamination.

BACTERIOLOGICAL EXAMINATION.

Bacteria are present in almost all natural waters. Most of these bacteria, which are ordinarily known as water bacteria, are harmless. The number and variety of these bacteria vary greatly in different places and under different conditions. The bacteria are washed into water from the air, from the soil, and from every imaginable object. The human excreta as well as those of animals pollute water with innumerable micro-organisms, but it is the infection with certain pathogenic organisms derived from fæcal matter, which renders water most dangerous to the consumers.

The object of bacteriological examination of water is to determine the number and the kind of micro-organisms it contains in a cubic centimetre. According to Koch there ought not to be more than 100 water bacteria per c.c. as a maximum number for a properly filtered water, but it is not safe to depend upon the number of bacteria alone for the purity of water. Roughly speaking the number of bacteria in water corresponds to the amount of organic pollution. Chemically pure water contains but few organisms, whereas water rich in organic matter contains them in abundance.

The examination should be conducted as soon as possible, after the sample of water has been taken, otherwise a large increase in the number of bacteria may take place.

Tests.—The following tests will suffice for the routine examination of water samples, when tests are carried out to determine the efficiency of the processes undertaken for the purification of waters for potable purposes :—

I. **Counting of Bacteria.**—This is done by adding a measured quantity of water (0.1 to 5 c.c. according to the condition of the sample regarding its purity) to 10 c.c. of liquid gelatine or agar. Although inoculation of both the media has been recommended, ordinarily agar alone which is more convenient a medium in a hot climate like India, will suffice. The agar after inoculation should be incubated at 37°C. for 24-48 hours. When gelatine is used the temperature of incubation should be 20°C. The count of bacteria growing at blood heat (37°C) is important as pathogenic and intestinal bacteria grow at this temperature. As far as possible, the media should be fresh, and distintly alkaline to litmus.

The following is the composition of the nutrient agar :—

Agar		...	25 grammes.
Peptone		...	10 grammes.
Salt		...	5 grammes.
Meat		...	1 pound.
Water	to	...	1000 c.c.

The whole is made alkaline with potassium hydrate solution.

(*a*) **Apparatus Required.**—

1. Agar-agar tubes plugged with cotton wool (sterilized).
2. Glass pipettes with rubber nipples.
3. A spirit lamp.
4. A tin in which the agar jelly may be melted. An old coffee tin will do for this purpose.

5. A tripod stand on which the above-mentioned tin may be placed while being heated by the spirit lamp.
6. A forceps for pulling out the cotton wool plug of the agar-agar tubes.

(b) The Procedure of conducting the Test.—

1. One agar-agar tube will be required for each test. Place as many tubes as are wanted in the tin. Pour into the tin enough water to make a layer about three inches deep.
2. Light the spirit lamp, put it under the tin and wait till the water boils. Allow it to boil for a minute or two to ensure all the jelly being melted.
3. Heat the pipette, from its mouth as far up and a little beyond the mark, in the flame of the spirit lamp, puffing air in and out, while doing so, by means of the rubber nipple. The object of this is to sterilize the tube. The glass should be heated so that it is just too hot to touch.
4. Allow the pipette to cool.
5. Take an agar-agar tube out of the hot water and cool it by shaking the lower end of it to and fro in a pot of cold water. Take it out every few seconds and feel it. It is sufficiently cooled as soon as it can be easily touched by the hand. The agar-agar jelly has the curious property that when heated it only melts at boiling point. When cooled it only sets again at or near blood temperature. Microbes are killed by boiling but not at blood-heat. Hence it is necessary to boil the agar-agar and also only to add the sample of water to the jelly when the latter has cooled nearly to blood temperature.
6. Fill the cooled pipette up to the mark with the water to be tested. The bottle should be shaken to mix the sample before it is taken out and the stopper together with the neck should be carefully heated over the spirit flame before the stopper is removed.
7. Pull the cotton wool plug out of the cooled agar-agar tube. Insert the end of the pipette between the mouth of the test tube and the cotton wool, and press the nipple so that the measured quantity of water is discharged into melted jelly.
8. Replace the cotton wool plug.
9. Tilt the test tube rapidly on its side and to and fro to give a rotatory motion to the tube several times so that the water and the jelly are thoroughly mixed.

10. Place the test tube on its side and leave it so till next day. Thus the jelly forms a thin layer along one side of the tube. The advantage of its being in a thin layer is that the colonies that will develop are easily seen and counted.
11. After incubation count and record the number of colonies found.

11. **Search for Bacillus Coli.**—The following is the procedure for the search for Bacillus Coli :—

1. Inoculate tubes containing bile-salt-lactose-neutral red-broth solution with the following quantities of water :—
   (a) One tube with 1 c.c. water sample.
   (A) (b) One tube with 5 c.c. water sample.
   (c) Five tubes with 10 c.c. water sample each.
2. Inoculate (A) at 37° C. for about 24 hours.
3. If acidity and gas are formed in any one or all (A) a loopful from each is inoculated into 10 c.c. sterile distilled water (B).
4. A loopful from (B) set is inoculated into another 10 c.c. tubes containing sterile distilled water (C).
5. Bile salt-neutral red-lactose agar plates are then inoculated with a loopful from each tube of (C) and incubated for 24 hours at 37°C. By this method organisms present in water and capable of fermenting bile salt-lactose-neutral-red broth are isolated. The distint red colonies from each plate are selected for the next step of procedure.
6. Tubes containing 10 c.c. of sterile distilled water are again inoculated from each plate with the colonies (D).
7. From (D) a further dilution is made similar to (6)-(E).
8. This set of (E) is used for inoculating the following :—
   a. Saccharose, *b.* Dulcite, *c.* Adonite, *d.* Inulin, *e.* Bouillon.
9. In case B. Coli be present the following reaction will be observed :—

1.	Saccharose	—	Motility	+
2.	Dulcite	+	Indole	+
3.	Adonite	—		
4.	Inulin	—		

The morphological characters of B. Coli present should also be noted.

Cases where the above indications are obtained the sample is considered to be contaminated with fæcal matter and as such condemned as unfit for potable purposes.

List of the Media used.—

a. Bile salt-lactose-neutral red solution—

Peptone	...	40 grammes.
Lactose	...	10 grammes.
Bile salt	...	10 grammes.
Neutral red (0.5 %)	...	6.6 c.c.

Normal sodium carbonate.—Till neutralized as indicated by neutral red; made up to 1000 c.c.

(For small quantity of water half the strength of the solution should be taken).

b. Bile salt-lactose-peptone-agar—

Peptone	...	20 grammes.
Lactose	...	10 grammes.
Bile salt	...	5 grammes.
Agar-agar	...	20 grammes.
Neutral red (0.5 %)	...	10 c.c.

N/1 Sodium carbonate.—Till neutralized and made up to 1000 c.c.

c. Bile salt-peptone-neutral red—

Sugar*	...	medium.
Peptone	...	10 grammes.
Bile salt	...	5 grammes.
Sugar*	...	5 grammes.
Neutral red (0.5 %)	...	5 c.c.
		to be made up to 1000 c.c.

Dr. S. N. Gore has devised a simple method for the bacteriological examination of water. It is based on the detection of indole-producing bacteria as these include not only all the true B. coli but many of the dysentery bacilli, the cholera and cholera-like vibrios, and other pathogenic bacteria. In this method an approximate idea of the total number of organisms per cubic centimetre—when they do not exceed about 50,000—growing on agar-agar is obtained by means of spreading a 5 m.m. platinum loopful and a 1 m.m. loopful of the sample each on an

* The particular sugar required (*i.e.*, Saccharose, Dulcite, *etc.*) should be taken.

agar slope. The 5 m.m. loop holds on an average 0.025 c.c. of water while the 1 m.m. loop holds about one-tenth of this quantity, *viz.*, 0.0025. On multiplying the number of colonies counted on the agar slope inoculated with the 5 m.m. loopful of the sample, by forty, and that on the slope inoculated with the 1 m.m. loopful, by four hundred, an approximate idea of the total number of bacteria per cubic centimetre of the sample is easily obtained. This method is so simple that it could be carried out in the field by any medical or even a non-medical man with a minimum of training.

The paraphernalia for this method consists of (1) a few small test tubes (3″ × ½″) containing about 0.5 c.c. of 5% Peptone solution and others containing about 2.5 c.c. of 1% Peptone solution, (2) a few agar slopes, (3) a 5 m.m. and a 1 m.m. platinum loop each mounted on an aluminium handle or a glass rod, (4) a measuring pipette marked at 2.5 c.c., 0.5 c.c. and 0.1 c.c., (5) a few sterilised test tubes, (6) a test tube holder, (7) a spirit lamp, (8) Böbmé's solutions*, (9) a thermos flask to serve as an incubator in places and seasons where the temperature happens to be below 25° C during the greater part of a 24 hours' day, and (10) a thermometer. All this apparatus could be arranged in a small box like Houston's water sample box.

THE ROUTINE METHOD.

1. Collect the sample of water in a sterilised test tube or one which has been sterilised on the spot by flaming.

2. By means of the pipette place 2.5 c.c. of the sample of water in the 5% peptone solution tube, and 0.5 c.c. and 0.1 c.c. each in two 1% peptone solution tubes. By means of the 5 m.m. and 1 m.m. platinum loops inoculate a third and a fourth 1 % peptone solution tube each with a loopful of the sample.

3. Lastly spread a 5 m.m. loopful and 1 m.m. loopful of the sample each on an agar slope. All the inoculated tubes should be marked accordingly.

4. Add sufficiently warm (about 40° C) water to the thermos flask, place the inoculated tubes in it, and stopper the flask.

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* Potassium persulphate	...	1 gramme.
Distilled water	...	100 cubic centimeters.
Para-dimethyl-amids-benzaldehyde	...	1 gramme.
Absolute alcohol	...	95 cubic centimeters.
Hydrochloric acid	...	20 ,, ,,

These two reagents are conveniently stocked in drop bottles.

5. After 24 hours remove the tubes, count the number of colonies that may have grown on the agar slopes and then examine the peptone water tubes for the presence of indole by Gore's cotton wool plug test in the following way :—

Remove the white absorbent cotton wool plug and moisten its lower surface first with a drop of the persulphate solution and then with one of the paradimethyl-benzaldehyde solution. Replace the plug and heat the upper layers of the culture in a low flame, as is done in applying the heat test for detecting albumen in the urine. If indole is present in the culture, the moistened under surface of the cotton wool plug will begin to become pink as soon as the liquid boils and volatilizes. If after a minute's boiling, the under surface of the plug does not show any pink colour the result is taken as negative. The testing for indole is commenced with the peptone solution tube containing the smallest quantity of the sample. For example in the set of five inoculated peptone tubes containing 2.5 c.c., 0.5 c.c., 0.1 c.c., and the loopfuls (= .025 c.c. and .0025 c.c.) of the water, the testing is commenced with the last tube, and if this proves negative, the next higher tube is examined for indole and thus the smallest quantity of water containing indole producer is determined.

Interpretation of Bacteriological Examination.—The bacteriological examination is much more important than the chemical examination. It is the most direct and delicate test of the safety of a water for drinking purposes, for by it we obtain exact information as to the evidence of sewage pollution regarding its potentiality to cause infective diseases. It is, however, very difficult to deduce the conclusions from the results of the examination, as this requires much experience and knowledge, especially in a country like India. Major Clemesha, I.M.S., has, therefore, proposed the following tentative standards for judging the bacteriological results of water analysis :—

Good lake water should contain—

(1) Less than 100 colonies per c.c. in agar at 37° C.
(2) No lactose fermenting organisms in 20 c.c.
(3) No non-resistant organisms in 50 c.c.
(4) Plentiful bacillus lactis aerogenes.

Usable lake water should contain—

(1) Less than 200 colonies per c.c. in agar at 37° C.
(2) No lactose fermenting organisms in 5 c.c.
(3) No non-resistant organisms in 20 c.c.
(4) Very plentiful bacillus lactis aerogenes.

Unusable lake water.—Bacillus coli found in 1 c.c. Fæcal organisms present in proportions similar to those of fresh Bacillus lactis ærogenes few or absent.

Good river water.—Less than 100 colonies per c c. No Bacillus coli in 50 c.c. Fæcal organisms not more than 1 in 10 c.c.

Usable river water.—Less than 300 colonies per c.c. No Bacillus coli in 20 c.c. Fæcal organisms not more than 1 in 1 c.c.

Unusable river water.—800 colonies per c.c. Bacillus coli 1 in 5 c.c. Lactose fermenting organisms 10 per c.c. Numerous varieties of fæcal organisms.

Deep waters.—Less than 50 colonies per c c No fæcal bacilli in 20 c.c.

CHAPTER II.

AIR.

AIR is absolutely necessary for the maintenance of life. A man can live a few weeks without food, a few days without water, but dies within three minutes, if he is deprived of air. The two main functions of the air that are especially concerned with health are interchange of gases in respiration, and regulation of bodily temperature. It should also be remembered that the combustion of the food in the body depends upon the oxygen of the air that is breathed, and that digestion and metabolism are stimulated and improved by an abundant supply of fresh air or rendered sluggish and retarded by prolonged exposure to polluted air.

The atmosphere, which is commonly spoken of as air, is the gaseous envelope encircling the earth. We do not feel or see it except in motion, when it is called wind. It offers resistance to our bodies while running. The air, like other gases, has weight, exerts pressure and has the power of diffusion and expansion. It is a mechanical mixture of several gases and not a chemical compound, because its chief constituents, oxygen and nitrogen, when brought together in the proportion in which they are found in the atmospheric air, do not exhibit any rise of temperature or any change in volume, while they may be separated by such simple physical processes as solution or diffusion ; again, the ratio between the weights of these two gases in air has no chemical relation to that of their atomic weights.

Besides oxygen and nitrogen there are also other gases present in small and variable quantities. They are argon, carbon dioxide, watery or aqueous vapour, ozone, ammonia, hydrogen and nitric acid, Organic matter and mineral salts

may also be found held in suspension in the air. The average composition of atmospheric air may be taken as follows :—

	Volumes per 1000.
Nitrogen ...	769.6500
Oxygen ...	206.5940
Aqueous Vapour ...	14.0000
Argon ...	9.3700
Carbon dioxide ...	0.3360
Hydrogen ...	0.0400
Ammonia ...	0.0080
Ozone ...	0.0015
Nitric acid ...	0.0005
Total ...	1000.0000

Nitrogen.—In the free state nitrogen exists in the atmosphere, of which it constitutes four-fifths by volume. It is a constituent of animal and vegetable tissues and no form of life can exist without it. It is incapable of supporting animal life or combustion. Its chief part in the air is to dilute oxygen and to render it less active, for pure oxygen is much too strong for healthy animal life. It is also an important factor in plant nutrition, as certain leguminous plants are able to assimilate the free nitrogen of the air by the help of bacteria.

Oxygen.—Oxygen occurs in the free state in the atmosphere, and though it forms about one-fifth by volume of air, it is its most important constituent as it is essential to both animal life and combustion. The amount of oxygen in the air is diminished by respiration, combustion, fermentation, putrefactive processes and trade and manufacturing operations as also by fog, while it is increased by vegetation and rainfall. It should, however, be noted that the percentage of oxygen in the air may vary from 15 to 50 per cent. or even higher without affecting the vital functions to an appreciable extent. It has been estimated that an atmosphere which contains only 11 to 12 per cent. oxygen is dangerous, and that containing 7.2 per cent. of oxygen generally proves fatal.

In submarines oxygen is replenished from the tank as soon as it drops to 16 per cent.

During respiration oxygen is withdrawn from the inhaled air, and is absorbed by the lungs. It then passes into the blood where it enters into feeble chemical combination with the *hæmoglobin* of the red blood corpuscles, and forms *oxyhæmoglobin*, which imparts to arterial blood its well-known bright red colour. It is lastly carried to all the tissues and cells of the body. The amount of oxygen that is absorbed varies with the age, condition of health and activity. During twenty-four hours a person on an average inhales about 34 pounds of air, which corresponds to a little over 7 pounds of oxygen. As the lungs absorb about one-fourth of the oxygen inhaled, it appears that the average amount of oxygen absorbed daily is nearly two pounds.

Argon.—The presence of argon in the atmosphere was discovered in 1894 by Lord Rayleigh and Professor Ramsay. It is an inert body, and does not enter into chemical combination with any other elements. It has not been found in the body, and has no hygienic significance.

Carbon Dioxide—This is called carbonic acid gas or carbonic acid anhydride. It is present in the atmospheric air in the proportion of 0.03 per hundred. For calculations in connection with ventilation the amount generally taken is 0.04 per cent. or 0.4 per 1,000. This proportion is liable to considerable variations. It is increased by respiration, combustion, fermentation, and various chemical actions in the soil and organic matter. The balance is, however, maintained by the green colouring matter of plants which, in the presence of sunlight, have the power of splitting up carbonic acid gas, absorbing carbon to build their tissues and setting free oxygen, but in the dark at night the action is reversed, that is, they take in oxygen and give off carbon dioxide. Rain and high winds also help to keep down the amount of carbon dioxide, the former by dissolving it, the latter by diffusing it.

The amount of carbon dioxide is greater in the air of towns than in the country and is greater in badly ventilated and crowded rooms than in properly ventilated rooms. The amount of carbon dioxide is usually taken as an index of atmospheric impurity, which is regarded as prejudicial to health and comfort.

Aqueous Vapour.—This is contained in the air in varying quantities in different localities and at different times, and mainly depends upon the temperature of the air. Air cannot contain more than a certain quantity of moisture at a given temperature ; and when it has taken up this maximum quantity, it is said to be saturated with aqueous vapour. The air thus saturated generally contains from 50 to 70 per cent. of this aqueous vapour. When the proportion of aqueous vapour present is more or less, the air becomes unpleasantly moist or dry. When air saturated with moisture is cooled, the vapour is deposited in the liquid form in very small droplets, known as mist, fog or dew.

Ozone.—This is an allotropic modification of oxygen—a compound molecule made up of three atoms of oxygen. It is formed when an electric discharge takes place. It is also formed in varying quantities during processes of slow oxidation taking place at ordinary temperatures.

Ozone exists in the air of the sea-shore and mountainous regions, but being a powerful oxidizing agent it is not met with in the air of towns or inhabited localities, as it is decomposed by the organic matter present in such air. It acts as an irritant to the respiratory mucous membrane, and may cause death, if inhaled in a highly concentrated form. It acts as a germicide, and in a strength of 1.34 parts of ozone per million of air by volume destroys bacteria in three to four hours.

Ammonia.—This is always present in air either free or combined, in minute traces rarely exceeding three parts in ten million of air. It is derived from the decomposition of nitro-

genous organic matter. The amount of ammonia in the air appears to be higher during the night than in the daytime. It is diminished after rain, because it is absorbed by the water during its downward passage through the atmosphere.

Nitric Acid.—Nitric acid found in the air is derived from electric discharges and also from industrial processes. Rain water falling during or immediately after a thunderstorm is found to contain nitrates and nitrites. Nitric acid is found more in the air about industrial towns and cities than in the air over country or sea.

Both ammonia and nitric acid, although present in very minute quantities in the atmosphere, play a very important part in the economy of nature. Plants, which are unable to obtain from the air the free nitrogen necessary for the development of their structure and fruit, derive it from ammonia and nitric acid which are washed out of the air by rain, and carried down into the ground.

Hydrogen.—Hydrogen is found present in the air of towns, country, mountainous regions, and also of the sea side. It is evolved during the fermentation and decomposition of certain organic compounds, and is present with the gases which escape from petroleum wells It is also evolved with other gases from volcanoes.

Suspended Matters.—Suspended matters may be considered as accidental impurities. They are always present in air in more or less quantities, probably except on the tops of mountains or near the sea. These are found floating in the air and are seen as motes in a sunbeam. Pasteur has shown that suspended matters can be removed from the air by filtration through cotton wool.

The suspended matters are both mineral and organic. The mineral matters are usually minute particles of common salt, sand, coal, clay and oxides of iron. The organic suspended matters are vegetable debris, pollens of grasses and flowers, minute seeds of plants, fine fragments of cotton, flax, wool,

etc. They also include the germs and organisms which produce fermentation, decomposition and disease.

IMPURITIES OF AIR.

The chief impurities are due to—

(*a*) Respiration,
(*b*) Combustion,
(*c*) Decomposition of organic matter,
(*d*) Dust.

(a) **Impurities due to Respiration.**—A healthy adult respires about 17 times in a minute, and with each act of respiration 500 c.c. (30.5 cubic inches) of air pass in, and out of, his lungs. During the process of respiration the carbon dioxide and watery vapour produced by the oxidation of carbon and hydrogen, which enter into the composition of animal tissues, are given off from the lungs. The expired air contains about 16 per cent. of oxygen, 3.5 to 4 per cent. of carbon dioxide, 5 per cent of watery vapour and a trace of organic matter. By comparing this with the composition of the atmospheric air it has been found that the proportion of oxygen is lessened by one-fourth and that of carbon dioxide increased by one hundred per cent. There is no change in nitrogen, which remains constant. Besides these changes, the temperature of the expired air is raised to nearly that of blood heat, viz., 98.04° F.

The amount of CO_2 exhaled by an average adult male at rest is considered to be 0.72 cubic foot per hour, one cubic foot during ordinary activity and as much as 2 cubic feet during hard work owing to increased metabolism. The amount of carbon dioxide given off by an adult female under similar circumstances is about one-fifth less, and the amount given off by an infant is 0.5 cubic foot per hour. In a mixed community at rest, including male and female adults and children, the CO_2 given off per head is, therefore, taken as 0.6 cubic foot,

The amount of watery vapour given off during respiration varies with the temperature, and humidity of the inspired air, and also with the work done by the individual. The average amount may be taken as 10 ounces for twenty-four hours. The average amount given off by the skin is about 20 ounces during the same period. Both taken together are enough to saturate the air with moisture, which is likely to cause discomfort in a room if proper precautions are not taken to change the air.

From modern investigations made by Mitchell, Billings, Haldane, Smith and others it has been conclusively proved that the lungs do not exhale volatile organic matter, which on reinhalation is poisonous to the human system. But the organic matter present in the air of an inhabited room is mostly derived from the volatile products emanating from decomposing particles of food lodged between the teeth, from putrefactive or pathological changes occurring in the upper air passages, from volatile fatty acids given off by dirty skins, and from emanations given off by clothes soiled by perspiration and other secretions. This organic matter is usually the cause of an unpleasant odour perceptible immediately on entering a crowded, badly ventilated room, especially when it is occupied by persons of uncleanly habits. It has been found that this organic matter is nitrogenous, oxidizable and readily putrescible, and forms a very good material of food for micro-organisms to grow. Milk, meat and other kinds of food become tainted when they come into contact with it.

Expired air contains fewer microbes in ordinary quiet respiration, but people suffering from influenza, pneumonia, diphtheria, tuberculosis, etc., exhale these pathogenic micro-organisms during coughing, sneezing and loud talking. These are then liable to infect other people living in the same room. These disease germs first get deposited on the mucous membranes of the nose, mouth and throat, most of which are got rid of by their excretions, though a few may manage to reach the air cells or bronchi.

(b) **Impurities due to Combustion.**—Coal, when burnt, constitutes one of the main sources of impurities of the atmospheric air. For the complete combustion of one pound of coal the average amount of air required is from 240 to 320 cubic feet. During combustion about one per cent. of coal is given off into the air as fine particles of carbon or soot and tarry products, together with large quantities of carbon dioxide and carbon monoxide. The other products of its combustion are carbon bisulphide, sulphurous and sulphuric acids, sulphuretted hydrogen, ammonium sulphide and water. The combustion of wood and charcoal results in CO_2 alone, when there is a sufficient supply of oxygen; but the monoxide is also produced when the oxygen supply is limited; as, for instance, in a room with doors and windows closed. These products of combustion, when they escape into the outer air, are rapidly diluted and diffused, but the solid sooty particles of carbon gravitate to the lower strata of the atmosphere, and are only dispersed by winds and rains.

Candles, oil and coal gas are used for artificial lighting. The first two add to the impurities of air by producing soot, carbon dioxide and water; while the latter adds to CO_2 and water the products of combustion of sulphur.

The light given out by a sperm candle burning 120 grains per hour is called one candle-power. The composition of such a candle is carbon 80%, hydrogen 13% and oxygen 6.6%. It gives off 0.41 cubic foot of carbon dioxide and the same amount of watery vapour to the air during its complete combustion.

Various kinds of oils are used for lighting purposes; the chief of which used in India are castor oil, cocoanut oil, rapeseed oil and kerosene oil. The last is much used owing to its cheapness and its strong illuminating power. Ordinary kerosene oil, on analysis, is found to contain 86% of carbon and 14% of hydrogen. It gives off on combustion 0.28 cubic foot of carbon dioxide and 0.22 cubic foot of watery vapour per hour.

In some of the big cities coal gas obtained by the destructive distillation of coal in large closed retorts is used for illuminating purposes. It is a mixture of varying quantities of a large number of distinct substances some of which are useful for heating or illuminating purposes, whilst some are hurtful and must be removed. Purified coal gas, on an average, contains 46% of hydrogen, 37% of marsh gas, 7% of carbon monoxide, 5% of illuminants (ethylene and acetylene) and 5% of nitrogen, sulphurous acid, etc. When burnt it gives off 50 to 60% of carbon dioxide, 16 per cent. of water and variable traces of carbon monoxide, sulphurous acid and ammonia. With complete combustion very little carbon monoxide is given off. Coal gas may, therefore, be harmful either from its products of combustion or from the unconsumed gas escaping into the house from leaky or broken pipes and defective fittings.

One cubic foot of ordinary coal gas yields on combustion 0.52 cubic foot of carbon dioxide, and 1.3 cubic foot of watery vapour, the vitiating element thus being the dioxide gas. An ordinary gas burner consumes on an average 4 cubic feet of the gas in an hour, and produces about 2 cubic feet of carbon dioxide. An incandescent gas light produces less carbon dioxide than an average oil lamp, and consumes less than half the amount of gas than an ordinary gas burner. It evolves half the heat, while its illuminating power is more than three times as great as the best ordinary gas burner.

From a hygienic point of view the electric incandescent lamp is the best, as it does not vitiate the air by any decomposition products, since it is contained in vacuum globes; nor does it heat up the air in the room to an appreciable extent.

(c) **Impurities due to Decomposition.**—Animal and vegetable matters, when they putrefy, give off offensive poisonous gases, such as CO_2, H_2S, NH_4HS, CS_2, NH_3, CH_4, etc. They mostly emanate from cesspools, sewers, drains, stables, cowsheds, etc. Besides, traces of ptomaines and

leucomaines may also be found in emanations from urinary and fæcal excretions of the animal body. Bacteria, moulds and fungi grow rapidly in such air. Food and meat are soon tainted, when exposed to it.

(d) **Impurities due to Dust.**—Dust is not only a nuisance, but under certain conditions is known to be prejudicial to health. It exists everywhere in the atmosphere, and should, in reality, be considered a normal constituent of the air, since it limits the humidity of the air by causing the moisture to precipitate in the form of rain, and helps in controlling the temperature by the formation of clouds, mists and fogs. Dust consists of solid particles of both organic and inorganic matter. Among the organic particles are found those of fat, scales of hair or skin, pus cells, dried particles of sputa, and dried scales of skin from those suffering from small-pox, measles, etc., floating in air.

Bacteria are the most important constituents of dust from the hygienic point of view. They are almost absent in sparsely populated districts, while they are more numerous in densely populated districts. They are also more evident in crowded rooms than in well-ventilated rooms. These bacteria are almost invariably non-pathogenic, though, under exceptional circumstances, the organisms of suppuration, tuberculosis, enteric fever and some other diseases have been found.

The inorganic particles of dust to be met with in the atmospheric air are chiefly composed of silica, aluminium silicate, carbonate or phosphate of lime, magnesia, sodium chloride, iron, carbon, etc. Those found in the air of houses are from the debris arising from the wear and tear of articles in domestic use, such as dust, soot and ashes. Mineral particles from neighbouring factories may likewise find access into houses.

All these minute suspended particles settle down on the floors, walls, and furniture on account of their weight,

in the confined air of the houses, but they may again be made to float in the air, when it is set in motion for purposes of cleanliness as in dusting and sweeping. It is, therefore, necessary that all furniture should be cleaned with a damp cloth *(jhuran)* and not flicked with a dry one. The durries and carpets should be taken out in the open air well away from the house, brushed and shaken at frequent intervals and exposed to sunlight. It is no use sweeping them inside the room as the disturbed dust will again settle on the walls and furniture. Bedrooms should not be crowded with furniture in order to leave as much unoccupied space as possible. The curtains should not be heavy and thick, but must be made of light muslin cloth, so that they can be washed at intervals.

EXAMINATION OF AIR.

The examination of air is conducted to determine odour, humidity, dust, micro-organisms, organic matter, carbonic acid, ozone and gaseous impurities.

Collection of Samples.—The collection of the samples of air to be analysed is very important. Large, wide-mouthed jars, with rubber caps, having a capacity of 4 litres should be used, after they have been thoroughly cleansed with distilled water and dried. Samples should be collected at the time when the atmosphere is likely to show the evidence of its greatest pollution. Thus in the case of a bedroom it should be taken when its occupants have been in it for some time. The following are the methods which may be used to collect the samples of air :—

1. Place the jar in a room, where a sample is to be taken and blow in air by bellows having a long nozzle reaching the bottom of the jar, so that the contained air may be displaced from its bottom.

2. Fill the jar with distilled water, and empty it by inverting it at the place where you have to take a sample. After it is drained dry, cover the mouth with an india-rubber cap.

The jars should always be labelled. On the label should be inscribed the capacity of the jar, and the temperature and pressure of the air observed at the time of collecting the sample.

Odour.—The presence of minute particulate matter is detected by perceiving a peculiar fœtid odour on first entering an inhabited room

from outside. After a time this is hardly noticed, as the sense of smell soon gets blunted. De Chaumont was the first to point out that this odour was due to the influence of atmospheric humidity on organic matter.

Humidity.—The presence of moisture or humidity may be ordinarily tested by putting ice in a glass vessel containing water when a film of moisture will be noticed to appear on the outer surface of the glass. The amount of its presence in the air is estimated by the hygrometer, the wet and dry bulb thermometer, or weighing it. This is done by aspirating a known volume of air through glass bulbs containing pumice stone saturated with pure sulphuric acid when the watery vapour will be absorbed, and the increase in weight of the bulbs will represent the amount of humidity or moisture in the air.

Dust.—A qualitative estimation may be made by Pouchet's ‌aeroscope. This consists of a funnel-shaped tube drawn out to a fine point, and brought almost in contact with a drop of glycerine smeared on a glass slide. The whole is enclosed in an air-tight chamber, and as air is aspirated through this, the dust is impinged on the viscid slide, which can be examined under the microscope.

A quantitative estimation may be made by drawing a known volume of air through a tube filled with pure sodium sulphate crystals. These are dissolved in water, and filtered through a filter paper of known weight. The paper is reweighed after it is dried. The increase in weight represents the quantity of dust present in the air.

Micro-organisms.—Hesse has devised an apparatus for estimating the number of micro-organisms in air. It consists of a hollow glass cylinder 50—70 c.m. long and 3—5 c.m. bore, one end of which is covered by a double india-rubber cap, the other end being connected with an aspirator of known capacity. The cylinder is first carefully sterilized, and then coated on the inside with 40 or 50 c.c. of sterilized nutrient gelatine, which is allowed to solidify. The outside rubber cap is now removed, a small pinhole is made in the inner cap through which 10—20 litres of air are slowly aspirated so that the micro-organisms may be deposited on the gelatine coating. The cylinder is properly plugged and incubated at 37° C. In two or three days the number of colonies which grow on the gelatine can be counted.

A simpler method suggested by Koch is to expose sterilized Petri dishes of gelatine or agar for short periods of time to the air to be examined. These are then incubated, and the number and kind of organisms determined.

Organic Matter.—This may be determined by slowly aspirating a known large volume of air through distilled water, and then examining the latter by Wanklyn's method as in water analysis. Carnelly's method is sometimes used, though it is not very reliable. In this method the amount of organic matter is determined by the volume of air required to decolourize a definite quantity of standard solution of potassium permanganate prepared by dissolving 0.316 gramme of the salt in a litre of distilled water. The solution is added to a jar containing the air sample, and shaken frequently, until its pink colour disappears.

Carbonic Acid.—The presence of carbonic acid or carbon dioxide may be demonstrated by exposing lime water in the air or passing a current of air through lime water, which will be turned milky owing to the formation of insoluble calcium carbonate. The amount of its presence is determined by the following methods :—

1. **Pettentkofer's Method.**—This consists in shaking up a known volume of air with a measured quantity of a 0.5 per cent. solution of barium hydrate, which absorbs carbon dioxide present in the air, and becomes precipitated as an insoluble salt of barium carbonate, so that less of the hydrate is left in solution. The strength of the solution of barium hydrate left after the experiment is determined, and the difference between the two calculations (before and after the experiment) denotes the amount of carbon dioxide present in the air. A standard solution of oxalic acid is used to estimate the strength of the baryta solution, and is prepared by dissolving 2.822 grammes of oxalic acid crystals in a litre of distilled water, so that 1 c.c. of the solution equals 0.5 c.c. of carbon dioxide at normal temperature and pressure. Phenol-phthalein is used as an indicator of neutrality, being crimson in alkaline but colourless in acid solutions.

2. **Lunge-Zeckendorff's Method.**—This consists of a 500th normal standard solution of carbonate of soda (.02 gramme per litre) coloured pink with phenol-phthalein as an indicator. The air is driven slowly through this by means of a bellows of a definite capacity, until the fluid becomes colourless from the carbonate being converted into the bicarbonate due to the absorption of carbon dioxide from the air. The number of bellowsful of air used is counted, and by reference to a table supplied with the apparatus the percentage of carbonic acid present in the air examined is obtained.

3. **Wolpert's Method.**—This is exactly the same, but the air is added in definite amounts and shaken in an apparatus.

4. **Haldane's Method.**—This requires a special apparatus, but it being portable, the analysis can be made on the spot, and thus the carrying to and fro of samples is avoided. The method consists in

subjecting 25 c.c. of air to exposure to the caustic potash solution which absorbs the carbon dioxide and the diminution in volume is measured under the same conditions of temperature and pressure, and the divisions on the narrow graduated portion of the burette are each $\frac{1}{10,000}$ th part of the capacity of the burette, so that the result is read off in parts per 10,000.

Ozone.—The property of ozone to liberate iodine from potassium iodide is generally made use of in detecting its presence. Strips of a white blotting or filtering paper dipped in a starch solution to which potassium iodide has been added become blue on exposure to the air containing ozone. This is a very delicate test, but it cannot entirely be relied on, as the oxides of nitrogen and the peroxide of hydrogen react similarly, and are also likely to be present in the air. Hence, a further test should be applied with a view to confirmation. For instance, test papers soaked in an alcoholic solution of "tetramethyl base" are not affected by hydrogen peroxide, but are turned violet with ozone. This is recommended as a more reliable test.

Gaseous Impurities.—Under this heading may be considered the following gases met with as impurities in the air:—

1. **Carbon Monoxide.**—The presence of carbon monoxide in air may be determined by Vogel's blood test with the spectroscope. It is based on the fact that carbon monoxide combines with *haemoglobin* of the blood, and forms a stable compound of *carboxyhaemoglobin*. The method of performing the test is as follows:—

Take 2 or 3 c.c. of blood in a wash-bottle and dilute it with distilled water till a faintly red colour is seen. Aspirate at least 10 litres of the air to be examined through it. The solution of the blood will at once develop a cherry-red colour if carbon monoxide is present in the air, and on examination with the spectroscope will yield a characteristic spectrum consisting of two absorption bands similar to those of *oxyhaemoglobin*, but slightly nearer to the violet end. The absorption bands of *carboxyhaemoglobin* do not, however, disappear on the addition of two drops of a colourless solution of ammonium sulphide, while the bands of *oxyhaemoglobin* will be replaced by a single broad and weakly defined band.

Haldane adopts a colourimetric method for estimating the amount of carbon monoxide present in air. His method depends upon the fact that a dilute blood solution has a yellow colour, but assumes a pink colour when saturated whith carbon monoxide. By comparing the colour with a standard solution of carmine the amount of carbon monoxide present may be determined.

2. **Ammonia.**—This can be absorbed by aspirating a definite amount of air through distilled water, and then estimated by Nesslerization as in water analysis.

3. **Hydrochloric Acid.**—To detect hydrochloric acid in air, a known volume of the air should be aspirated through a dilute solution of caustic potash, when potassium chloride would be formed. The chlorine in the solution is then determined by means of a standard solution of silver nitrate.

4. **Sulphurous Acid.**—This is absorbed as in the preceding, and titrated with a standard permanganate solution.

5. **Sulphuretted Hydrogen.**—This gas is absorbed by passing air through a lead acetate solution, and estimated as the black sulphide of lead.

CHAPTER III.

VENTILATION.

EVEN though the atmosphere is being polluted in so many ways, the composition of the air has been found to be constant almost everywhere. Even in big cities the air of the open spaces differs very little in its composition from that of the places remote from habitation, for instance, mountains, valleys and seas. This is because air is purified by great natural forces, such as wind, rain, oxygen, ozone and chlorophyll of plants.

Wind dilutes and carries away impurities to a distance and brings pure air instead. Rain absorbs several gaseous and solid suspended impurities, and carries them down with it in its fall on the earth. Oxygen and ozone oxidize the organic matter present in it, and the chlorophyll of plants takes up carbonic acid. But in the case of larger towns and congested cities these natural forces are unable to effect this necessary exchange of impure air and, therefore, the process of ventilation has to be relied upon largely in purifying the vitiated air of dwelling houses.

The term "ventilation" means the removal or dilution, by a supply of fresh air, of all the unwholesome gases and suspended impurities collected in dwelling houses. This process of exchange is known as internal ventilation; but to admit fresh air into houses it is necessary to look to the ventilation of streets and to the surroundings and positions of the dwellings, which is called external ventilation. There must not be too many residences on any part of the site. All dwelling houses must be constructed with due interspacing and in regular lines, so that each house may have the advantage of the prevailing wind which is a natural force for purifying the air by diluting and carrying away its impurities to a distance and bringing in pure air instead. Where small

huts are built scattered in the midst of large and lofty buildings as in factories and warehouses, or where houses are crowded together irregularly having only a few narrow and blind alleys, the air naturally stagnates in them, as the current of the wind suffers obstruction by the larger and loftier buildings in the vicinity. Also the light of the sun cannot have access into such dwellings, and hence the humidity is also greater. The death-rate in such places is especially high. The vitality of persons living in them is very much lowered, and they are predisposed to attacks of diseases caused by impure damp air. Houses built "back to back" or with the courtyard crowded with outhouses for cattle, etc., are equally bad and unhealthy. Plenty of space in front, if not all round it, must be provided for each dwelling. The streets and roads must be broad and wide, the minimum width being 40 to 50 feet ; but the streets, which are meant to be used for heavy traffic of carriages should be 60, 80 or 100 feet wide. In India it is necessary to have broader streets than in England, where the winds are more prevalent and less stagnant, and where a constant interchange of air is going on owing to the air currents set up by differences in temperature between the inside and outside of dwelling houses. The streets should be laid out straight, and should intersect one another at right angles. No projections of any kind likely to interfere with the free passage of air should be allowed over the streets. Trees should be planted on the footpaths in such a way as to give shade but not to obstruct the ventilation. There should be many open spaces and parks as they are considered the lungs of a town, and factories of manufacturing processes should not be allowed to be erected near any habitation. The drains and sewers should always be kept clean, and the roads should be well watered, so that the dust may not float in the air.

Amount of Fresh Air needed.—An average adult exhales 0.6 cubic foot of CO_2 per hour which cannot be distinguished by smell from the pure air, but if the CO_2

exceeds 0.6 per 1,000, the air begins to be perceptibly close to a person entering from outside and this is regarded as the standard of efficient ventilation. The quantity of CO_2 present in towns is, on an average, 0.4 per 1,000 cubic feet, and therefore 0.2 cubic foot of CO_2 per 1,000 of air, or 0.0002 per cubic foot of air is considered the **permissible limit** of impurity.

By dividing the amount of CO_2 exhaled in an hour by the permissible limit, the late Professor de Chaumont suggested the number of cubic feet per hour required for one person. This is expressed by the equation $D = \frac{E}{R}$, where D = the delivery of fresh air expressed in cubic feet, E = the amount of CO_2 exhaled per hour per head, *i.e.*, 0.6 cubic foot, and R = the respiratory impurity allowed per cubic foot of air. Therefore $D = \frac{0.6}{0.0002} = 3{,}000$ representing the number of cubic feet of fresh air required per individual per hour. Similarly, if D and E are known, we can find R. In the case of an individual doing gentle work in a room and giving off 0.95 cubic foot of carbon dioxide per hour the amount of fresh air required per hour would be 4,750 cubic feet, and in the case of an individual doing very hard work and giving off 1.8 cubic foot of carbon dioxide per hour 9,000 cubic feet of fresh air would be required per hour to keep the impurity down to the permissible limit. It should, however, be remembered that from their recent experiments Carnelley, Haldane and Anderson have demonstrated that 1 cubic foot of carbon dioxide per 1,000 of air for dwellings and 1.3 for schools can be taken as a standard of limit instead of 0.6 cubic foot of carbon dioxide.

The minimum amount of fresh air needed for sick persons should generally exceed that required by healthy persons by at least one-fourth. However, in round numbers the amount should be 4,000 cubic feet of air per hour.

The amount of air required for artificial lights is 2,250 cubic feet of air per hour in the case of a gas burner, the same quantity as is required by an adult man in the case of a paraffin lamp, and half of this in the case of a candle.

In mines 6,000 cubic feet of air per hour are required to keep up the energy of the working people.

It is necessary that animals should be supplied with fresh air. Like human beings they keep better health in well-ventilated sheds and stables. The amount of fresh air needed for housing them well depends upon their body weight, a common rule being to allow at least 25 cubic feet of it per pound of the body weight. Thus a cow or a horse ought to have from 10,000 to 20,000 cubic feet of air per hour. In fact the animals ought to be kept in the open air as far as practicable.

Amount of Cubic Space needed.—The amount of cubic space required for each person is a thousand as would be available, for instance, in a room 10 feet long, 10 feet wide and 10 feet high. Under such conditions, even if the whole amount of air inside it be exchanged three times in an hour necessary through wind or ventilation, it would not cause injurious draught in the cold weather. A larger cubic space is apparently unnecessary, as it encourages stagnation of air, but in the case of temporary failure of wind or other means of ventilation, it has an advantage of affording a reserve of air and becoming vitiated less rapidly than a small space. A larger cubic space per head should be provided in small rooms than in large ones, as the latter are more easily ventilated than the former.

In public halls, theatres, etc., much less cubic space, *viz.*, 250 to 300 cubic feet is, as a rule, allowed per individual, as these buildings are occupied only for short periods. In hospitals, where sick people are congregated, organic matter and organisms are given off in large amount; hence at least 1,200 cubic feet should be allowed to each patient, and the floor area should be at least one-twelfth of the cubic space.

In jail barracks the minimum superficial and cubical space allowed to each prisoner is 36 square feet and 648 cubic feet, and in jail hospitals 54 square feet of superficial area and 900 cubic feet of air space are allowed for each patient. A

separate cell for solitary confinement should have a cubical capacity of 1,000 feet and a ground area of 75 square feet.

Having thus determined the amount of air and cubic space required for an individual it is now necessary to consider how the ventilation of a room can be accomplished. There are two methods of ventilation. One is called natural and the other is artificial.

Natural Ventilation.—This depends for its action upon, (1) the diffusion of gases, (2) the differences in weight of masses of air of unequal temperatures, and (3) the wind.

(1) **Diffusion of Gases.**—Gases diffuse with a velocity which is inversely as the square root of their densities (Graham's law) and thus the air of rooms diffuses through cracks and crevices of doors and windows even though they are closed and also through bricks and mud-walls ; but one cannot depend on diffusion alone, as it is unable to remove the solid impurities that tend to gravitate to the floor.

(2) **Differences in Weight of Masses of Air of Unequal Temperatures.**—According to the law of physics heat expands and cold contracts. The air heated by products of respiration of men or by fire and rendered more moist expands, and being lighter bulk for bulk than the cold air, rises and escapes through openings. The equilibrium is maintained by the cold air rushing in to occupy its place from outside. Too much reliance cannot be put on this force, as there is very little difference in India between the outer air and that inside the dwellings.

(3) **Wind.**—The wind is a powerful ventilating agent, and acts by perflation and aspiration. Perflation means the forcing of the air through open doors, windows and even through porous bricks into the room as a result of the movement of natural air currents. Aspiration signifies the sucking action of the wind which draws air out of a space that it is blowing across. Thus a wind blowing across a

chimney or past a window tends to aspirate or suck the air from the room, and into the partial vacuum thus created fresh air rushes in to take its place. A strong wind, however, is likely to offer an obstruction to the efficient operation of this method of ventilation as it presses the ascending column of air back into the conduit. To obviate this difficulty, a cowl is constructed over a chimney. It is either fixed or rotatory,

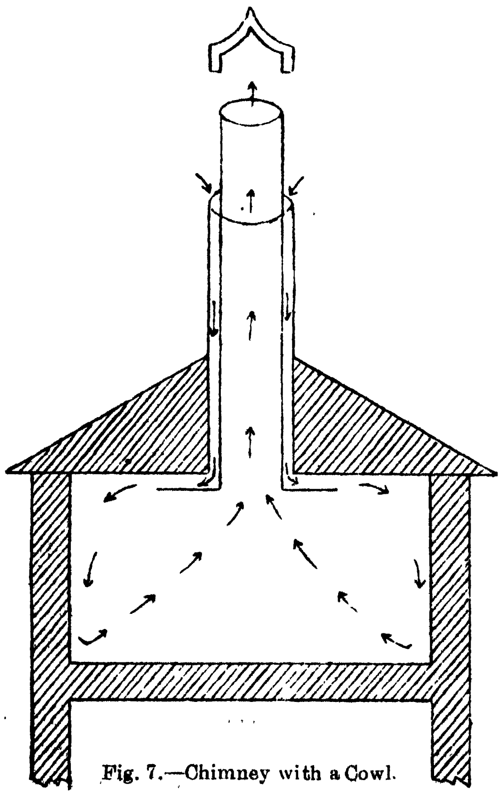

Fig. 7.—Chimney with a Cowl.

but ordinarily it has been found to be inefficient in its action, though it may prevent ingress of foreign bodies, birds and insects and may also serve as a protection againt rain. In India the action of the wind is largely relied on for ventilating

houses, but the difficulty arises when the wind is blowing very forcibly, or when it entirely fails. For small rooms of moderate height efficient natural ventilation is secured by providing a sufficient number of doors and windows. These should be placed opposite to each other, and should be kept open as much as possible. If it is not possible to place windows in opposite walls, the next best arrangement is to place them in adjacent walls. To keep the room cool it is advisable to have its height from floor to roof more than 12 feet, *viz.*, 15 feet or even more, in which case openings for the exit of the foul hot air should be provided near the ceiling or in the roof, so that it may not accumulate in the space between the tops of the windows and the ceiling.

For seasons when doors and windows have to be kept closed, as also for cold countries where these have usually to be kept closed, several devices of ventilating openings known as inlets and outlets have been suggested. These should be kept clean from dirt, so that they may not become choked up.

Inlets.—For admitting fresh air inlets should always be placed 5 to 6 feet above the level of the floor, and be directed obliquely up towards the ceiling to avoid cold draughts. To prevent cold draughts or excessive warmth the proportion of the inlet ought to be 1 square inch for every 60 cubic feet of room space or 24 square inches, *i.e.*, 6 inches by 4 inches for each individual, so that the velocity of the air entering the room must not exceed 5 feet per second. A velocity of 2 to 3 feet is the most satisfactory.

As a further aid to an efficient working of these inlets, their openings should be constructed on a conical design, their wider mouth being placed towards the room and the narrower towards the exterior. When it is intended to deliver heated air through the inlets, their openings should be constructed near the floor. The process of heating a column of air for diffusion into the room consists in allowing

it to pass either over hot water pipes or through an air chamber provided behind a stove or a grate.

Types of Inlets.—The following are the chief types of inlets, which are commonly used :—

(1) **Inlets in Windows.**—*a.* **Hinckes-Bird's Method.**—In this the lower sash of the window is permanently raised upon a block of wood 4 inches deep and runs the entire length of the window, so that it leaves an interval of space between the upper and lower window-sashes through which fresh air can pass from without inwards.

b. **Louvred Window Panes.**—These resemble a venetian blind in their arrangement, and can be closed and opened at will.

c. **Cooper's Ventilator.**—This is used in railway carriages. It consists of a series of apertures in the window glass pane, arranged in a circle, which is capable of moving on a central pivot.

d. **Hatton's Hopper Ventilator.**—This is usually used as a substitute for the upper half of the window or a part of it if large, and is made to fall inward. It not only serves the purpose of a window sash, but acts as a ventilator, and when so acting, not only prevents direct draughts, but screens the air from particles.

(2) **Inlets in Walls.**—The types of inlets applicable to the outside walls of rooms are :—

a. **Ellison's Bricks.**—These are perforated with conical holes, the wider ends opening inside, so that the air passing through them becomes gradually distributed over a gradually increasing area, and thus does not cause a draught.

b. **Sheringham's Valve.**—This is a vertical flap door fixed on each side of the room 5 or 6 feet from the floor, balanced by a counterpoise, and hinged below so as to fall forward towards the room ; it is closed in at the sides and

front, so that the air current can only pass upward through a perforated plate, which has an opening of 9 inches by 8 inches, *i.e.*, an area of 27 square inches.

c. **Stevens' Drawer Ventilator.**—This is like a drawer lacking its back. It is made to fit into a hole in the wall in such a way that the air can enter only when the drawer is open.

d. **Jenning's Inlet.**—This is another variety which allows a varying amount of air to enter into the room by opening it to a greater or less extent.

(3) **Special Air Inlet Shafts.**—The best known types are—

a. **Tobin's Tube.**—This consists of a large upright and rectangular tube about 5 or 6 feet high placed against or inside the wall of a room. The lower end opens on to the outside wall, so that the fresh air is directed upwards. The incoming air may be purified by making it pass through a layer of wool, or moistened by impinging it on a tray of water or warmed by passing it over heated pipes.

b. **McKinnell's Tube.**—This is very useful for a room, which has no other apartment over it. It consists of two tubes one inside the other and carried upwards through the ceiling. The inner one which acts as an outlet, projects beyond the outer tube, both above and below, and may be made more efficient by heating the air by gas burners or lamps placed at the bottom of it. The outer one, which is a short but wide tube, acts as an inlet, the fresh air being deflected towards the sides of the room by a horizontal rim attached to the longer and narrower inner tube. The apparatus is fixed in the roof, and is well adapted for large one-storeyed buildings, such as churches, halls, schools, etc.

Outlets.—These are meant for the escape of impure air. They should be of the same size as inlets, and should always be placed in or near the ceiling, as heated impure air tends to rise. The lamps placed near the outlets assist the escape of

foul air. With terraced roofs the simplest plan is to insert a 9 or 12 inch pipe through the terrace fitted with a cover

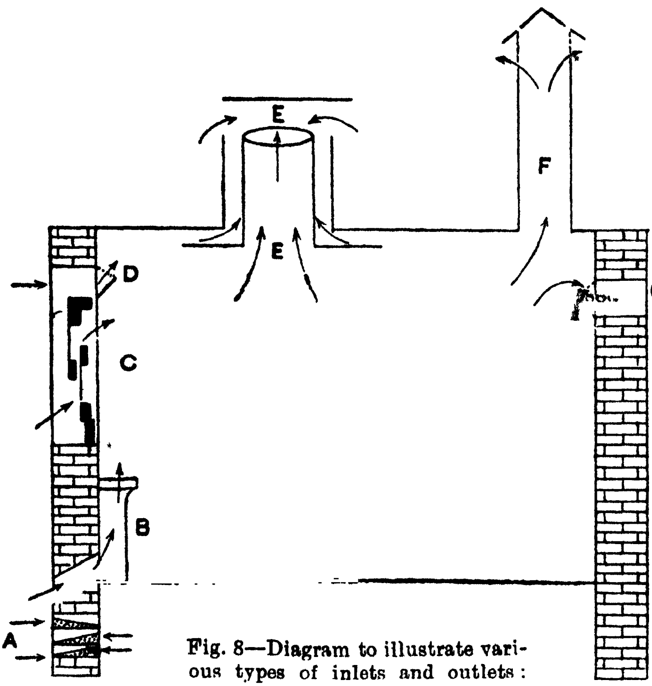

Fig. 8—Diagram to illustrate various types of inlets and outlets:

A, Ellison's Bricks; *B*, Tobin's Tube; *C*, Hinckes-Bird's method; *D*, Hopper Ventilator; *E*, McKinnell's Tube; *F*, Ventilator Shaft; *G*, Sheringham's Valve.

and wire gauze round the openings. Ridge ventilation may be used with tiled roofs. If there is a chimney in the room, the outlet may be provided by placing a shaft either around the chimney or against one side of it. The forms of this arrangement are Arnott's valve and Boyle's valve.

Arnott's valve consists of a light metal flap opening into the chimney flue near the ceiling. It allows impure air to

be sucked into the chimney, but closes up tightly on any down-draught in the latter. **Boyle's valve** consists of mica flaps. The clicking noise made by this apparatus may be obviated by using silk instead of mica.

Artificial Ventilation.—In this system mechanical means are used to facilitate the renewal of air. It is designed to work only when all the doors and windows are kept closed. The three methods, which are in use, are (1) the plenum method, (2) the vacuum method, and (3) a combination of the plenum and vacuum methods.

(1) **The Plenum Method.**—In this method the air is mechanically propelled into buildings through conduits by means of large rotary fans or blowers working in circular boxes, and the foul air escapes by the greater pressure in the room through special openings. The fans may be run by electricity, gas or steam power. The air in this method should always be introduced low down and extracted from the upper part of the rooms.

(2) **The Vacuum Method.**—This method consists of the mechanical extraction of the air out of the room by means of extraction shafts. The best example of ventilation by extraction is the action of an ordinary open fire with a chimney placed in a room. The fire heats the neighbouring air, which expands, ascends and is replaced by the colder air from without. The ventilation of mines is ordinarily secured on this principle. Air is first made to pass down the down-cast or intake shaft, and then made to pass through all the workings before it reaches the upcast shafts; at the bottom of which a furnace is provided.

Theatres, public halls and hospitals are very often ventilated on this extraction principle.

The air in the extraction shaft may be heated by gas, steam or hot water pipes. Extraction by fans is often used. A fan is placed at the top of a shaft, and is made to revolve

by a gas engine. This is specially used in the textile trades in the cotton, woollen, silk, and flax factories.

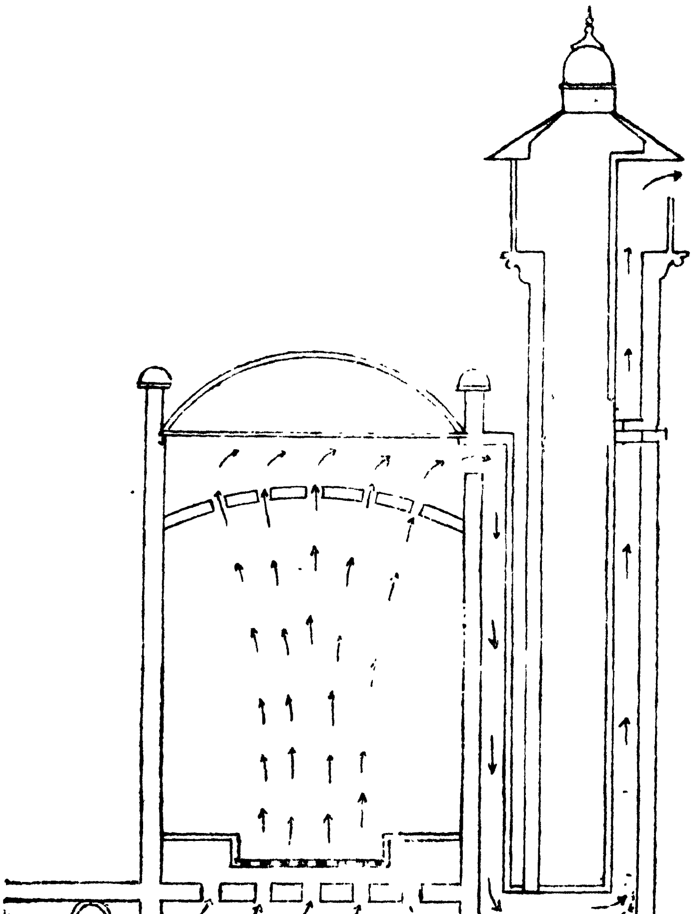

Fig. 9—Ventilation of a Big Hall by "Extraction" System.

(3) **The Combined Method.**—The combined method is probably the most satisfactory. When the plenum and

vacuum systems are combined to ventilate large buildings, such as public halls, theatres, hospitals, workshops, etc., power in the shape of a fan is used to force the air in, and power, either heat or a fan, is also used to draw the air out of the rooms.

The chief advantages of artificial ventilation are that the air can be warmed, cooled or filtered as necessary before allowing it to enter the building, but the disadvantage is that such air being liable to lose much of its freshness in its passage through long shafts is likely to cause lassitude, and a feeling of depression among the inmates. Again, the installation and maintenance of the system are very costly.

Effects of Overcrowded and Ill-ventilated Rooms.—Persons living in badly ventilated and overcrowded rooms of houses, schools or factories usually suffer from lassitude, headache, vertigo, nausea, vomiting and even collapse. In extreme cases death may result as in the historical case of the Black Hole of Calcutta and the recent tragic case of Moplahs who were shut up in a small railway van. Leaving alone these extreme examples people who live in rooms with deficient ventilation for a prolonged period suffer from loss of appetite, indigestion, debility and anæmia. They lose the capacity for work and are soon overcome with fatigue. Owing to reduced metabolism and lowered vitality they are predisposed to the attacks of certain infectious diseases, such as influenza, pneumonia, tuberculosis, etc.

It was formerly assumed that these evil effects were due to changes in the chemical composition of the air resulting from respiration, *viz.*, increase of carbon dioxide, diminution of oxygen and presence of poisonous organic matter, but recent experiments of Leonard Hill and others have shown beyond doubt that they are due to physical changes in the air, *viz.*, increased temperature, humidity and stagnation. These appear to have a direct connection with the heat regulating mechanism of the body. In a crowded room, where the air is hot, stagnant and loaded with moisture, the watery

vapour given off by the skin is entangled under the clothes and forms a saturated layer of an "aerial envelope" which prevents further evaporation from the skin. This causes flushing of the skin, rise of the surface temperature and other symptoms resembling those of heat exhaustion. It is a matter of every day experience that the air kept moving by means of fans lessens to a great extent the ill-effects of a warm and stuffy room, and generally stimulates the system. It also increases the loss of heat from the body by increasing the evaporation of the perspiration of the skin, as the stagnant, saturated "aerial envelope" formed around the body is dissipated by the air in motion.

Overcrowding is, as a rule, met with in the houses of the poor people. Hence the minimum standard of cubic space allowed per adult in tenement houses should be at least 400 cubic feet for rooms which are used both as living and sleeping rooms, and 300 cubic feet for rooms, which are solely used as a workplace. Half the amount should be for children. Some municipalities have made bye-laws which enjoin that every dwelling room of a tenement house should have a clear superficial area of 144 square feet and a height of at least 7 feet 6 inches. Such rooms should also have a door and a window, but they do not lay down the maximum number of individuals to occupy such rooms, with the result that these rooms are, as a rule, overcrowded, and much of the space is occupied by household furniture.

Determination of the Efficiency of Ventilation of an Inhabited Room.—In determining the efficiency of any scheme of ventilation, the cubic space of the room must first be ascertained. This can be determined by multiplying the length, breadth and height of a room, if it is regular in shape, but a height above 12 feet in ordinary dwelling-rooms need not be taken into consideration for calculating the cubic space. Solid articles of furniture must be deducted from the cubic content. For a bed 10 cubic feet and for an adult 3 cubic feet are usually deducted. In the case of an irregularly shaped

room it is convenient to divide it into rectangles and triangles, and to add together the cubic contents of each. The following rules of mensuration may be helpful in obtaining the cubic content of a room :—

Mensuration of Superficial Surfaces.

(1) Area of a circle = Square of Diameter × 0.7854.

(2) Circumference of a circle = Diameter × 3.1416.

(3) Area of an ellipse = Product of both diameters × 0.7854.

(4) Circumference of an ellipse = Half the sum of both diameters × 3.1416

(5) Area of a segment of a circle

$$= (\text{Chord} \times \text{height} \times \tfrac{2}{3}) + \frac{\text{height}^3}{2\,\text{chord}}.$$

(6) Area of a square, rectangle, rhombus, or rhomboid, the opposite sides of which are parallel = Base × perpendicular.

(7) Area of a triangle = Base × 1/2 perpendicular.

(8) Area of a parallelogram = Bisect into two triangles by a diagonal, and take the sum of the areas of the two triangles.

(9) Area of a trapezoid, two sides only being parallel = Mean length × perpendicular.

(10) Area of a trapezium or any irregular figure = Areas of triangles into which the figure may be divided.

(11) Surface of a sphere = Diameter^2 × 3.14159.

Mensuration of Cubic Spaces.

(1) Cubic capacity of a cube or solid rectangle = Length × breadth × height.

(2) Cubic capacity of a solid triangle = Area of triangle × ½ height.

(3) Cubic capacity of a cylinder = Area of one end × length.

(4) Cubic capacity of a cone = Area of base × height × ⅓.

(5) Cubic capacity of a dome = Area of base × height × ⅔.

(6) Cubic capacity of a sphere = Diameter^3 × 0.5236.

The next step is to ascertain the number of occupants in each room. The allowance of cubic feet of air per head per hour multiplied by the number of occupants gives the total number of cubic feet of air to be supplied per hour. The direction of the air currents must then be determined. This can be ascertained by examining inlets and outlets. Inlets can be distinguished from outlets by observing the directions of

the smoke emanating from smouldering brown paper or cotton velvet when held close to the apertures. The sum of the superficial areas of inlets or outlets divided by the number of occupants will give the inlet or outlet area per individual.

The rate of velocity of the air is usually tested by employing an anemometer and observing the numbers of feet of air which it records as having passed in one minute. The instrument should not be in the centre of an inlet, but at a point about two-fifths of the diameter from its side, as this point best gives the mean velocity. If the instrument be placed in this position for one minute, the volume in cubic feet of air, which flows in, is arrived at by multiplying the area of the inlet by the linear velocity recorded by the instrument. Celluloid bulbs filled with hydrogen may also be used to estimate the rate of velocity of the air.

The temperature of the air of the room at the inlets and outlets should be taken.

Besides these points it is well to inspect the outside of all rooms to find out if any rubbish, filth, etc., is lying about.

CHAPTER IV.

HEATING AND COOLING.

HEATING.

IN India artificial heating of a building does not become necessary except in the north and hill stations, where the cold is very severe during winter. Heating and ventilation are so closely associated, that no system of heating that does not, to some extent, assist ventilation, should be considered. In any system of heating, heat is distributed by radiation, convection and conduction. In radiation the heat rays pass in straight lines to the nearest objects, where they are absorbed or reflected, just as the sun's rays pass through space independent of the atmosphere. . There is no substance known, which absorbs all the heat radiated upon it, but dull black objects absorb more heat than bright ones, and lamp-black or soot is said to absorb more than 90 per cent., whatever be the source of heat. In conduction the heat absorbed by bodies passes through them from particle to particle. Metals are good conductors of heat, but air is a bad conductor. Convection is the process by which heat is conveyed to the various particles of liquids and gases. In this process the heated particles being lighter rise up, and their place is taken up by cold particles carried down from above, and thus the convection currents are established.

The chief methods of heating are six, *viz.*, (1) Open fires; (2) Stoves; (3) Gas fires; (4) Hot air; (5) Hot water or steam pipes; and (6) Electricity.

1. **Open fires.**—In India rooms are ordinarily heated by open *angethies*, in which charcoal is burnt, but in better classes of houses a fireplace with a flue attached to it is coming largely into use, in which coal or firewood is burnt. The open fireplace heats a room chiefly through radiation,

It has the advantage of being cheerful and a good ventilator, but has the disadvantage of being very unequal in its heating effect in different parts of the room, as the intensity of radiant heat varies inversely as the square of the distance from its source. It is also wasteful of fuel, as it burns about 8 lbs. of coal per hour, and the heat available in warming the room is only one-sixth or one-eighth of the total heat generated, and the rest is lost in unconsumed smoke or cinder, and in the hot gases passing up the chimney. These disadvantages can be minimised to a great extent by attending to the following points in constructing a fireplace :—

1. Little iron should be used in its construction ; the back and sides should be made of fireclay so as to retain much heat and give it out slowly when the fire begins to fail.

2. The sides should be splayed widely out, and the back should be bent forward so as to facilitate radiation of heat.

3. The flue should be throated and provided with a movable mantle, and the outlet should be made as narrow as possible in order to economize heat.

2. **Stoves.**—These consist of coal or charcoal fires in a cast-iron stove, which is joined to a flue to carry away the products of combustion. The heating of the room is largely done by convection. These stoves are easily overheated, render the air excessively dry and give rise to unpleasant odours by the organic dust in the air being charred from falling upon the hot surface. The gases of combustion, such as carbon dioxide and carbon monoxide escape through the joints of the stove and the flue, and may cause poisonous symptoms or even death. Hence their joints should be made strong and air-tight and the stove should be coated on the inside with fireclay or silicate, or it should be made of earthenware or wrought iron instead of cast iron.

There are many forms of ventilating stoves, which are provided with an air-duct under the floor for driving cold

fresh air into a chamber surrounding vices adopted in actually is heated and then ascends into the room. Stoves have disadvantage of making the air hot and dry, which causes dryness of the skin and mucous membranes, irritation of the throat and thus predisposes to cold and respiratory affections. This objection may be met by placing shallow vessels of water on the stoves, from which evaporation will take place and keep the air moist.

3. **Gas Fires.**—These are handy and clean, do not form ashes, and are useful in warming small rooms, such as bedrooms, where they are used only for a short time. They can also be used for cooking purposes. They must always be provided with a flue of sufficient size to conduct away the gases of combustion either into a chimney or to the oustide. In gas fires, asbestos contained in the grate is heated to redness by means of a Bunsen burner.

4. **Hot Air.**—The fresh air is driven into a basement furnace, where it is heated, and then supplied to the various rooms in the house by means of a series of air ducts. This is largely used in Russia and America.

5. **Hot Water or Steam Pipes.**—In this system the rooms are warmed by means of hot water or steam circulating in a system of closed pipes. The hot water system is especially applicable to small buildings, and steam pipes to large buildings. Hot water may be used under low pressure or under high pressure (Perkin's system). When water is heated under low pressure a boiler is provided at the lowest part in the basement with an inlet pipe or return below and, an outlet or flow pipe above. The pipes usually from 2 to 4 inches in diameter are provided at intervals with radiators, and an open hot water cistern is situated at the highest part to allow of expansion of the water. Radiators serve to increase the heating surface and are known as "direct," if they are exposed directly in the room so as to warm it by radiation and convection. They are known as "indirect," when they are placed under the floor so

It has the advantage of being over them, before it enters the room through gratings provided. In the indirect system the radiators are placed in a special box against an outside wall, where the air from outside is heated, and this heated air passes by thermal circulation through ducts into the rooms where wanted.

In Perkin's high pressure system the water is heated under pressure of three or four atmospheres. It consists of wrought-iron pipes, $\frac{7}{8}$ths inch in internal diameter and $\frac{1}{4}$ inch thick, to withstand the internal pressure. No boiler is employed, but one-sixth of the total length of the pipes is coiled and heated in a furnace. The heat causes the water to expand, and to circulate through the pipes; 8 feet of this high pressure pipe and 12 feet of the low pressure pipe are considered sufficient for heating an air space of 1,000 cubic feet.

6. **Electricity**.—This is an expensive method of heating a room. Resistance coils are used as radiators, which heat the room mainly through radiation and convection. The system is very clean, as no products of combustion are formed, and is easily regulated.

COOLING.

In India the artificial cooling of the dwelling rooms becomes a necessity from a health point of view during the summer months, when the day temperature rises to 112° F., or even more, and the hot winds are blowing forcibly throughout the greater part of the day.

Underground cellars or *tykhanas* often seen in old houses of Northern India are quite cool, and may be used during the hot day, if they are fitted with electric fans.

To keep the rooms of a house cool the window glass panes are generally painted green, the doors and windows are kept closed, and thick heavy curtains or screens are hung on the verandahs from 8 or 9 in the morning to 4 or 5 in the evening, so as to prevent the passage of radiant heat and hot

air into the rooms. But the devices adopted in actually cooling the temperature of the room depend upon the principle that when a body passes from the liquid into the gaseous state, it absorbs or renders latent a large quantity of heat. This heat is taken from the surrounding objects which, therefore, become correspondingly cool. Water is used for this purpose, as it has a greater latent heat than any other substance.

The time-honoured swinging *punkhah* hung up from the ceiling causes greater movement of air ; hence it aids the rapid evaporation of perspiration from the body, which feels much cooler. A better result may be obtained by attaching a moist sheet of towel about a yard wide to the *punkhah* frill. Electrically worked fans are certainly a great improvement in this matter, as they increase considerably the velocity of the movement of the air. The incoming fresh air may be cooled to an appreciable extent by blowing it by means of a thermantidote or fan-wheel over a moist screen or a "*khas khas tattie,*" kept at the door or window (inlet), and constantly kept moist by a spray of water flowing over it. If water is from a suspicious source it is much safer to permanganate it before it is used. Cooling of a room may also be produced by the expansion of air. Thus, if a jet of air were driven into a room under a pressure of ten inches of mercury above the ordinary barometric pressure, the sudden expansion of this compressed air would reduce the temperature to a great extent. But in all these artificial methods of cooling a room efficient ventilation can only be carried out, if there are sufficient outlets in size and position.

An installation[1] for artificial cooling of a room has been in use at the Calcutta School of Tropical Medicine for the past few years, with the most satisfactory results. It was designed and constructed by the late Mr. Wilcox of Calcutta on the suggestion of Lieut.-Col. J. W. D. Megaw, I.M.S.,

1. Ind. Med. Gaz., Nov. 1924, p. 572.

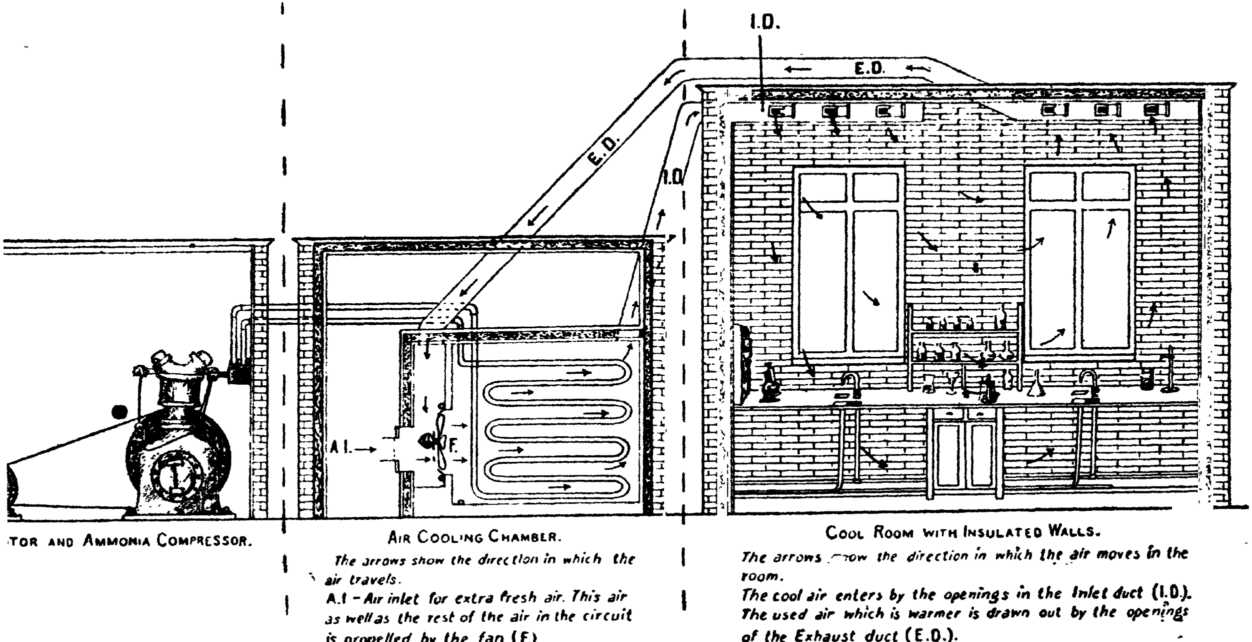

Fig. 10—Diagram of the Cool Room.

(*From the Director, School of Tropical Medicine, Calcutta*).

Director of the School. The room is insulated and is supplied with air which is passed over the coils of an ammonia refrigerating plant. The cool air is forced into the room by means of an electric fan which is also utilized for driving away the hot vitiated air of the room. Extra fresh air can be introduced into the circuit in any desired quantity to ensure good ventilation. The diagram shows the main features of the installation.

The following are the advantages of the system :—

1. The air of the room can be maintained at a suitable temperature, irrespective of the climatic conditions.

2. The air of the room can be kept as dry as is desired.

3. The room is well lighted and well ventilated.

4. The air can easily be made dust proof and insect proof by filtering the inlet air over cotton wool.

The only drawback connected with the system is its cost.

CHAPTER V.

INDUSTRIAL HYGIENE AND OCCUPATIONAL DISEASES.

INDUSTRIAL HYGIENE.

VARIOUS industries are developing in India in rapid strides. Hence it is essential that industrial hygiene should be included in the curriculum of medical schools and colleges. It deals with the health, the welfare and the human rights of a vast population of the working classes. It is a subject, which is directly connected with the social and economic conditions of these people, and aims at the carrying on of the industries under conditions as little injurious as possible to them.

In order to improve the hygienic conditions under which people work, and in order to prevent the incidence of occupational diseases, the Governor-General of India in Council passed in 1911 an Act called the Indian Factories Act (Act No. XII of 1911), modified it in 1922 mostly on the draft conventions and recommendations adopted by International Labour Conferences, and further amended it in 1923, the amended Act being called Act No. IX of 1923. According to this Act the Local Government can appoint inspectors, who can enter any factory and inspect its premises and machinery and the prescribed registers, which he thinks necessary for carrying out the purposes of the Act. By virtue of his office the District Magistrate is a factory inspector under this Act.

The Act defines a factory as any premises wherein or within the precincts of which, on any one day in the year not less than twenty persons are simultaneously employed and steam, water or other mechancial power or other electrical power is used in aid of any process for, or incidental to, making, altering, repairing, ornamenting, finishing or otherwise adopting for use, for transport or for sale any article or part of any article ; or any premises wherein, or within the precincts

of which, on any one day in the year not less than ten persons are simultaneously employed and any such process is carried on, whether any such power is used in aid thereof or not which have been declared by the Local Government, by notification in the local official Gazette* to be a factory.

Construction of Factories.—The plans of new factories must be submitted to the factory inspector for his approval before their construction is taken in hand. The foundations must be well laid, and the supporting walls and superstructure must be very strong to bear the weight of the heavy machinery, with which the factory will be equipped. The factory should be sufficiently lighted, and the doors of every room in the factory in which more than 30 persons are employed should, except in the case of sliding doors, be so constructed as to open outwards. There should also be adequate provision for the escape of the persons employed in the case of fire occurring in the factory. To avoid overcrowding in any room of a factory, a floor area of at least 36 superficial feet and a breathing area of at least 500 cubic feet should be allowed for each worker. The general ventilation in every room of a factory must be so efficient as to render harmless, as far as practicable, any gases, vapours, dust or other impurities generated in the course of the work carried on therein that may be injurious to health. If necessary exhaust fans or other mechanical means must be provided to prevent this nuisance.

Humidity.—When the textile fibres contain a certain amount of moisture, they become elastic, and then easily carded, drawn out, spun into yarn and woven into cloth. Hence it becomes necessary to increase the humidity of the atmosphere of the factory rooms, which also increases their temperature. Workmen exposed to such conditions are liable to be fatigued soon, and thus the efficiency of work falls considerably.* They are also apt to attacks of catarrhal colds, bronchitis, pneumonia, tuberculosis and other respiratory affections, especially when the air is also surcharged with

organic dust emanating from cotton fibres. To avoid these bad effects on the health of the operatives it is necessary to lay down a maximum standard of temperature and humidity to be maintained in the workrooms of every factory. But in a country like India, where the climatic conditions vary so much in every province, it is difficult to lay down any standard. Again certain textile processes require a high temperature and a high degree of humidity. However, the temperature should not exceed 100° F. in any room of a factory in winter or in summer, and for humidity the temperature in the wet and dry-bulb thermometers should vary between 70 and 80° F. Hence these thermometers must be kept in the rooms, and readings taken daily at certain hours.

In his report[1] on humidification in Indian cotton mills Mr. T. Maloney, Government advisor on humidification, makes the following recommendations :—

(1) It is desirable to fix a standard of ventilation for all factories and workshops in India.

(2) The standard of ventilation demanded for different trades should take cognisance of the class of work performed, and the degree of atmospheric cooling power demanded should be increased in accordance with the degree of muscular activity demanded by the work.

(3) For cotton mills throughout India, the ventilation should be such as to give a minimum cooling power of 11 million calories per square centimetre per second at a height of 5 feet in position usually occupied by an operative in the performance of his ordinary duties. This standard is very much lower than that recommended for sedentary workers in other countries, but would be sufficient to prevent visible perspiration in the majority of cases and would represent a vast improvement in the cooling powers usually found in weaving sheds during the greater part of the year.

1. The Leader, Oct. 4, 1928, p. 9,

(4) Such a standard should be equally applicable in all departments and in all processes of cotton manufacture, irrespective of whether humidity is artificially introduced into the room in which the particular process is carried on or not.

(5) Artificial humidification by the introduction of live steam should be prohibited when the dry bulb temperature of the department reaches 85° F.

(6) In shed buildings in which any process of cotton manufacture is carried on, the use of corrugated or galvanised iron as a roofing material should be prohibited unless (*a*) covered by tiles, slates, or other roofing material, or (*b*) under-drawn by wooden boards ar least ¾ inch in thickness, or similar non-conducting material, or (*c*) the average height of the room is more than 20 feet, or (*d*) roof arrangements are made whereby the roof is kept cool by spraying with water whenever the shade temperature exceeds 95° F.

(7) It is not essential to make the whitewashing or water-spraying of roofs of all shed buildings compulsory during the hot weather, but mill agents and managers are recommended to adopt generally these methods of reducing room temperatures.

(8) In case where the factory inspector deems it advisable, he may be given powers to order roofs of shed buildings or the roofs of storey buildings to be whitewashed or sprayed with water.

(9) The system of ventilation and humidification adopted in mills should be more extensively adopted in new mills of suitable construction, owing to its very great advantage as a cooling plant.

It should be noted that the water used for the purposes of producing artificial humidity should be taken either from a public supply of drinking water, or from some other source of water ordinarily used for drinking, or should be effectually purified before being used for the purpose of producing humidity.

In factories in which women and children are employed, and in which the floors are liable to get wet, adequate drainage must be provided for removing the excess of the fluid.

Sanitary Accommodation.—Every factory must be provided with sufficient and suitable latrine accommodation and with separate urinal accommodation for the persons employed in the factory. There should be at least three latrine seats in a factory employing not more than 50 operatives. Four latrine seats should be provided when 51 to 150 operatives are employed, and five latrine seats when 151 to 200 operatives are employed. For a factory employing more than 200 operatives one latrine seat for every 50 or fraction of 50 operatives is considered sufficient, provided there is adequate urinal accommodation. When women are employed, separate latrines properly screened off should be provided for them. The latrines must be placed, though detached from any other factory building, at a convenient and accessible position, and must be well ventilated and lighted. When any general system of underground sewerage is in force in a municipality, all factory latrines and urinals should be connected with the sewerage system. When no underground drainage sewerage system exists, the dry-earth system with separate vessels for solid and liquid excreta must be adopted, and arrangements maintained for the regular removal and disposal of excreta. All drains carrying waste or sullage water should be constructed in masonry or impermeable material, and should be regularly flushed and connected with some recognized drainage line.

Water Supply.—In every factory a supply of pure potable water should be provided from either a general municipal water service, or one or more wells so situated as not likely to be polluted. When taps are not used, a suitable establishment must be maintained for the drawing, protection and distribution of the water. Proper arrangements must be made for maintaining, in a drained and cleanly

condition, the area around the spot set apart for the distribution of the water.

General Cleanliness.—The compound of a factory should be maintained in a strictly sanitary and cleanly condition. All the inside walls and ceilings or tops of the rooms of every factory whether polished or not and all the passages and staircases, if they have not been painted with oil or varnished, once at least within seven years, should be limewashed once at least within 14 months, and if they have been so painted or varnished, should be washed with hot water and soap once at least within 14 months. The floors of factories should be swept at least once a week or oftener, if to do so is necessary to maintain them in a cleanly condition.

Accidents.—With a view to prevention of accidents, all mill-gearing and other parts of the machinery, such as fly-wheels, water-wheels, hoists, teagles, hoist-wells, trap-doors or similar openings near which any person is liable to pass or be employed must be securely fenced, when these are in motion or use. Women and children are forbidden to clean any part of the mill-gearing or machinery of a factory, while the same is in motion, or to work between the fixed and traversing parts of any self-acting machine, while such machine is in motion. Women and children are also not employed in the part of a factory for pressing cotton in which a cotton opener is at work.

Every accident which occurs in a factory causing death or bodily injury, whereby the person injured is prevented from returning to his work in the factory during the forty-eight hours next after the occurrence of the accident, has to be notified to the factory inspector and to other authorities appointed by the Local Government. To encourage the workmen the Workmen's Compensation Act (Act No. VIII of 1923) was passed by the Indian Legislature and came into force on the first of July, 1924. It makes it compulsory on certain classes of employers to compensate their workmen for certain

diseases or injuries sustained in their employment, or in the event of the workman's death, those dependent upon him.

In every factory there should be a provision of a first-aid box or boxes in a readily accessible room, where minor wounds should be at once dressed after they are treated with tincture of iodine or some other suitable antiseptic to avoid further infection, and in serious injuries workmen should be removed to a neighbouring hospital on a stretcher provided in the factory immediately after first aid. It is also necessary that a few of the more intelligent workmen should be trained in first-aid and ambulance work to the standard of St. John's first-aid certificate. It may be mentioned that in accordance with the rules framed under the Bihar and Orissa Mining Settlements Act, 1920 every owner, agent and manager of a mine is required to train in ambulance work to the standard of St. John's first-aid certificate one or more of the workmen employed in a mine in which 50 persons or more are employed underground during any period of 24 hours, and to provide a suitably constructed stretcher or stretchers and a box or boxes containing a sufficient supply of splints, bandages, adhesive plaster, boric acid, vaseline, cotton wool, tincture of iodine or other suitable antiseptic solution.

Hours of Work.—It is not possible to lay down any general rule for the hours of work, which may vary with the character of the employment. However, it is much better that a man should work for eight hours, devote eight hours to the development of his intellectual, moral and physical welfare, and sleep for the remaining eight hours. The hours of work, however, depend to a large extent upon the physical exertion required, upon the nervous tension and upon the sanitary conditions in which work is carried on. There should certainly be one full day's rest once in a week.

According to the Indian Factories (Amendment) Act, 1922, the period of employment for men and women of and over 15 years of age in any factory is fixed at eleven hours a day with

an interval of an hour's rest after six hours' work, the maximum period of work being sixty hours in a week. This is a very small improvement on the Indian Factories Act passed in 1911, inasmuch as men had to work especially in textile factories for twelve hours a day with an interval of half an hour's rest after every six hours of work. But there is no improvement in the case of women, who are still employed for eleven hours a day. There should be a provision that women should not be employed in mines on underground work, and that married women should never be engaged in night work.

The continuous work for long hours is certainly detrimental to the health of the mill hands, especially when the atmosphere in the mills is so close, sultry and vitiated and when so much of fluff and cotton fibres are floating in the air in some departments. It has been observed that the families of operatives working in such mills become extinct in three generations.

To improve the health of the women it is necessary, that they should have two or three days' rest each month during the menstrual period, and should be protected from undue strain and fatigue. They should also not be allowed to work during the last two months of pregnancy and for one month after delivery. Compensation should be granted to them for the loss of wages during this period.

A crêchê or day nursery should be provided in a factory, where a large number of women is employed. The crêchê should be in charge of one or two trained nurses who will look after the infants when the mothers are working in the factory. The mothers should also be given facilities to leave their work at times and go to the crêchê to suckle their infants.

For purposes of employment in factories persons under fifteen years of age are considered children. Children under twelve years of age are not employed in factories. Between twelve and fifteen years of age they are employed in factories for six hours a day with a period of rest of not less than

half an hour. It is necessary that the children must be in possession of a certificate showing that they are not less than twelve years of age, and are fit for employment in a factory. These certificates are granted by a certifying surgeon, who usually happens to be the Civil Surgeon of a district. It is time that the Government should appoint certifying surgeons in big industrial towns who should also act as factory inspectors, as through their special training they are better qualified to make necessary recommendations as regards the ventilation, overcrowding, cleanliness, sanitary conveniences, humidity, temperature, offensive effluvia, and the physical conditions of the employees. In the case of children, attendance at school during the non-working hours of the day must be made compulsory, so that they may be able to develop their mental and intellectual faculties.

Owing to long hours of work in mills and factories, especially in a tropical country like India the workers get exhausted at the end of the day, and owing to the absence of any sort of recreation take to the evil habit of drinking which is ruinous to them as well as to their family. Hence it is very essential for social workers to start welfare work among the workers in mills, factories and workshops. They should start labour clubs, where the workers should collect in the evenings after the day's work, and could obtain light refreshments at cost price. In these clubs there should be a reading room, where the literate workers can read newspapers or periodicals. There should also be an arrangement for indoor games. There should be an arrangement for wrestling and other Indian games on the play grounds, and also for cinema films or *kathas*. Social workers should start night schools for the education of grown up men and women employed in factories and should hear the grievances, individual as well as collective, of workers and try to get them redressed by making suggestions to the employers. They should visit the homes of the workers and advise them as to how they should keep their homes and their surroundings neat and clean.

OCCUPATIONAL DISEASES.

The occupational diseases are mostly produced by the air of the factories polluted by poisonous gases, fumes and dust emanating from the manufacturing processes. These affect the workers especially when they have to work in insanitary and overcrowded factory rooms up to a fatiguing point.

Poisonous Gases and Fumes.—The following are the most important :—

1. **Carbon Dioxide.**—Carbon dioxide is formed by the combustion of all ordinary fuels, and is given off in the process of fermentation in breweries, paper works or sewers, and in certain chemical processes. It occurs frequently in deep wells, excavations and cellars containing old damaged grain. It is found in the neighbourhood of lime-kilns and brick-kilns which are in operation. It also forms the *choke-damp*, or *after-damp*, of the coal mines. The percentage of carbon dioxide in the air that will prove fatal to human beings who inhale it is not definitely known. Air containing 2 or 3 per cent. of carbon dioxide hardly produces any injurious effects on the human system. The only effects noticed are an increase of 50 per cent. in the depth of breathing as observed in moderate exercise. Respirations increase in depth proportionately with the increase in the percentage of carbon dioxide upto 5 per cent. when a person begins to pant, and suffers from the distressing symptoms of dyspnœa accompanied by headache, chilliness and nausea, when the percentage reaches 7 or 8 in the air. However a certain tolerance for the gas may be acquired, and air contaminated with as much as ten per cent. of the gas may be breathed for some time without any serious effects. An atmosphere containing a concentration of 30 per cent. of carbon dioxide exercises a direct toxic action on the nerve cells, and produces unconsciousness ending in death by asphyxia.

2. **Carbon Monoxide.**—This gas is the product of the incomplete combustion of coal or wood in closed rooms,

and is evolved in large quantities in gas works, coke ovens, blasting furnaces, cement and brick-kilns and in the Leblanc process of soda manufacture. Hence individuals employed in these works mainly suffer from its poisonous effects. Carbon monoxide is also given off in the exhaust gases from motor cars, and is responsible for serious and occasionally fatal cases of poisoning which have occurred when the engine of a motor car has been allowed to run in a closed garage.

The gas is extremely poisonous, and more deadly in its effects than the dioxide as it forms a more stable compound, carboxyhæmoglobin, with the hæmoglobin of the blood than oxyhæmoglobin, and therefore prevents oxygen from being given to the tissues. Air containing 0.05 per cent. of carbon monoxide may cause unpleasant symptoms, and w..n 0.2 or 0.3 per cent. is capable of destroying life if inhaled for a considerable time, whilst a concentration of 0.4 per cent. may cause death in one hour. In acute cases the first symptom is the loss of motor power, which causes the individual to fall, so that he is unable to escape from the danger, even though he is aware of it. Unconsciousness then rapidly supervenes. In less acute cases the chief symptoms are dizziness, headache, vomiting, palpitation and profuse perspiration. In fatal cases coma passes into death, sometimes preceded by convulsions. In chronic cases the chief symptoms are depression, anæmia and psychoneurosis. Carbon monoxide has no odour, and thus not being liable to irritate the air passages, is not usually discerned by its victims.

3. **Carbon Bisulphide.**—This volatile liquid of disgusting odour is used in the arts as a solvent for caoutchouc, india-rubber, phosphorus, sulphur, etc. Hence the workers by constant exposure to its fumes in ill-ventilated caoutchouc factories often suffer from symptoms of chronic poisoning, such as headache, noises in the ears, nausea, anorexia, tremors, muscular weakness and ataxia. In some cases peripheral neuritis, paralysis of the extensor muscles, delirium, mania and even dementia also develop.

As a preventive measure troughs containing carbon bisulphide should be covered, and the fumes emanating from them should be removed by means of exhaust fans. Workers should not be allowed to take their meals in rooms, in which carbon bisulphide is used and they should be examined medically at least once a month.

4. **Sulphuretted Hydrogen.**—This has an offensive smell like that of rotten eggs. It is a powerful poison in a pure state, causing death instantaneously, but, when largely diluted, it produces dizziness, nausea, headache and even convulsions.

Lehmann's experiments[1] show that an atmosphere containing 0.7 to 0.8 of sulphuretted hydrogen per 1,000 litres of air produces in man dangerous symptoms in a few minutes, while air containing 1 to 1.5 per 1,000 destroys life immediately. According to Vivian Lewes death occurs in one and a half minutes when air contains 0.2 per cent. of the gas. The sudden death of men working in sewers is sometimes supposed to be due to the inhalation of this gas.

The poisonous effects of sulphuretted hydrogen are mostly met with in persons employed in chemical and gas works, in the cleaning of boilers, in soap factories where large quantities of fat are decomposed, and in the treatment of sulphuric acid to remove arsenic.

In nature sulphuretted hydrogen is formed during the decomposing process of organic substances containing sulphur. It is, therefore, found about privies, burial vaults, marshy places, and collections of filth and manure, but the quantity is too small to influence seriously the health of the inhabitants. However, owing to its action on lead and silver, it blackens the paints of pictures and silver articles, when present in the atmosphere even to a very small extent.

1. Rosenau, Preventive Med. and Hyg., Ed. IV, p. 948.

5. **Sulphur Dioxide.**—This has a suffocating odour, and is very destructive to plant life, high and low. Those who are employed in the manufacture of sulphuric acid and in such processes as ore burning and the bleaching of cotton and worsted goods are usually apt to suffer from its deleterious effects. It has, as a rule, very little effect on healthy persons, but persons suffering from respiratory troubles like asthma and bronchitis are liable to be worse by inhaling it. The usual poisonous symptoms from it are a feeling of suffocation, dyspnœa, coryza, cough, opacity of cornea, cyanosis and convulsions.

6. **Chlorine and Hydrochloric Acid.**—These are evolved from alkali works, and act as irritants of the mucous membrane of the respiratory tract and conjunctiva.

Chlorine, if inhaled in small quantities, produces cough, dyspnœa and bronchial catarrh, and produces great respiratory distress and immediate death, if inhaled in large quantities.

The fumes of hydrochloric acid are much less irritating, but workers constantly exposed to it even in small quantities, suffer from ulceration of the trachea, bronchitis, pneumonia, irritation of the eyes, as also from destruction of their teeth.

7. **Ammonia.**—This is evolved in works where ammonia and ammonium salts are manufactured, as well as in certain other trade processes. Its fumes produce conjunctivitis, and rarely suffocation and death.

8. **Benzene.**—This is one of the tar products of coal distillation, and is used in rubber works, dry cleaning processes, manufacture of aniline, etc. Inhalation of its fumes produces excitement, flushed face, nausea, vomiting, pain in the abdomen, giddiness, headache, cyanosis, stupor, coma and death. Workmen, who are habitually exposed to its fumes, suffer from a chronic form of poisoning with purpuric hæmorrhage from the mucous membranes of the nose and throat and into the skin, and fatty degeneration of the heart, liver, and kidneys.

9. **Aniline**.—Aniline is largely used in industrial arts for making several dyes. Poisoning occurs through absorption by the skin and some times through inhalation by the lungs. A certain amount of tolerance is established, though it has apparently a cumulative effect.* The symptoms are eczematous ulcerations, cough, nervous symptoms and blindness.

10. **Nitrous Fumes**.—These are met with in the manufacture of nitric and sulphuric acids, and also in the manufacture of explosives. The fumes chiefly irritate the respiratory tract, and may produce death if inhaled for a long time.

Dust.—This is the great enemy of working people. It is a product of the various industrial occupations, and is found in the form of fine solid particles suspended in the air, which are of mineral, animal or vegetable origin. The inhalation of these particles causes catarrh, bronchitis, pneumonia and fibroid phthisis. If the particles are hard, sharp and angular, instead of being smooth and rounded, they are particularly injurious, as on being embedded in the air cells of the lungs they cause irritation and inflammation of the surrounding tissues. Workmen who have to work in hot, closed, overcrowded and ill-ventilated factories with air saturated with aqueous vapour suffer more than persons working in the open or well-ventilated workshops.

Coal miners are not so much affected by phthisis as tin miners, even though they work in mines with air vitiated by respiration, combustion and blasting, because coal particles are very minute, have no sharp angles, and are supposed to be capable of preventing the development, and arresting the growth, of tuberculosis; but they generally suffer from nystagmus owing to deficient illumination in the pits of coal mines.

Potters in India do not seem to suffer from bronchial affections as they work at their proverbial wheel in the open,

but in England they suffer from bronchitis, emphysema (potter's asthma) and phthisis as they have to work in closed, heated factories, and are exposed to sudden variations of temperature.

Steel grinders suffer largely from phthisis, bronchitis and pneumonia, but the diseases can be averted by introducing improved methods of ventilation. Grinding should be done under water, and metallic and stone dust should be collected in extraction tubes attached to each grindstone and removed by exhaust fans; or magnetic shields should be used to attract and collect the steel dust. In addition to these, the workers should wear respirators.

Lead Poisoning.—Lead poisoning being one of the commonest industrial diseases has of late years received a large amount of attention from the public. The chief industrial occupations in which lead poisoning is liable to occur are white and red lead works, pottery manufacture, electrical accumulator works, enamelling and painting industry, smelting metals, glass and file cutting.

Lead is introduced into the system by inhaling or swallowing dust and fumes or volatilized particles containing lead or its compounds. It is said that it may gain access into the body by direct absorption through the skin, but Sir Kenneth Goodly[1], Special Medical Referee for industrial poisoning, has never seen a case of lead poisoning occurring in the industry of rolling "tea lead" notwithstanding the fact that the men's hands are soiled with lead oleate from day to day. The chronic form of lead poisoning is more commonly met with in industry than the acute form. The chief symptoms of chronic poisoning are constipation, colic, blue line on the gums, anæmia, rheumatic pains in the muscles and joints and paralysis, especially of the extensor muscles of the hands and feet, known as dropped wrist and dropped foot. In addition

1. Lead Poisoning in Industry, State Jour. of Med., March, 1922, p. 102.

to these there are arteriosclerosis, interstitial nephritis, lowered resistance to infection, e.g., tuberculosis, and lead insanity or apoplexy.

The precautions to be adopted are as follows :—

1. Women and children being particularly susceptible to lead poisoning should not be employed in lead factories. Pregnant women are particularly predisposed to abortion or still-births.

2. Workmen should take drinks containing minute doses of sulphuric acid or soluble sulphates as also a lot of milk. The former acts by rendering the ingested particles of lead chemically inert by converting them into insoluble lead sulphate. They should also cleanse their mouth, teeth and gums with a solution containing a soluble sulphate, such as sodium or magnesium sulphate.

3. "Dry rubbing" used in the process of making white lead paint is dangerous owing to the evolution of lead dust. Hence wet waterproof sandpapers should be used, as they do not produce the dust but a mere white mud, which should be washed off into a pail and disposed of.

4. The following regulations in connection with operations involving the use of lead compounds are given in Part II of the Schedule of the Indian Factories (Amendment) Act, 1922 :—

1. Where dust or fume from a lead compound is produced in the process, provision must be made for drawing the fume or dust away from the persons employed by means of an efficient exhaust draught so contrived as to operate on the dust or fume as nearly as may be at its point of origin :

2. The persons employed must undergo the prescribed medical examination at the prescribed intervals, and the prescribed record must be kept with respect to their health :

3. No food, drink, or tobacco, shall be brought into, or consumed in any room in which the process is carried on, and

no person shall be allowed to remain in any such room during meal times :

4. Adequate protective clothing in a clean condition shall be provided by the employer and worn by the persons employed :

5. Such suitable cloak-room, mess-room and washing accommodation as may be prescribed shall be provided for the use of the persons employed :

6. The rooms in which the persons are employed, and all tools and apparatus used by them, shall be kept in a clean condition :

Phosphorus Poisoning.—Phosphorus poisoning occurs among persons who are exposed to the vapours arising from the handling of phosphorus either in its manufacture or in the manufacture of matches. The chief symptoms of chronic poisoning are headache, anorexia, muscular pains, anæmia, necrosis of the jawbone (phossy jaw) and cachexia. The long bones become brittle and are liable to fracture under very slight violence.

Match manufacturers used to suffer largely from the symptoms of chronic poisoning owing to the use of yellow or white phosphorus in the manufacture of matches, but this danger has now been obviated by the substitution of red or amorphous phosphorus, which is non-volatile and thus harmless. The Phosphorus Matches Prohibition Act was passed in 1913, and in 1919 the Government of India agreed with other European countries to adhere to the Berne Convention of 1906, by which the manufacture, importation, and sale of white phosphorus matches were prohibited. "Strike every where matches" can now be made from an odourless non-poisonous compound of phosphorus, *viz.*, sesquisulphide of phosphorus. Safety-matches are harmless. The heads of the match sticks are tipped with a mixture of potassium chlorate, potassium dichromate, red lead, and antimony sulphide. They are ignited by being struck against the side

of the match box to which is applied a paste consisting of antimony sulphide and red phosphorus.

Precautions.—Work-rooms should be large, roomy and well-ventilated, and should be provided with exhaust fans or flues to drive away all the fumes of phosphorus from the workers. If possible the work should be carried out in the open air. Workers should be enjoined to observe personal cleanliness, and should not be allowed to take food or drink in the work-rooms. The workers should be examined medically at periodical intervals, and if any carious teeth are found they should be extracted. They should gargle the mouth with alkaline solutions of sodium carbonate or lime water and charcoal. Turpentine is recommended as an antidote of phosphorus poisoning. Hence sponges soaked in turpentine should be hung round the necks of the employees or saucers containing turpentine should be kept in the work-rooms so that the employees may inhale the air impregnated with turpentine.

Mercury Poisoning.—Mercury volatilizes even at ordinary temperatures and is absorbed into the system through the lungs, mouth and also through the unbroken skin. The trades in which mercury or its compounds are used and in which mercurial poisoning may occur are bronzing, vermilion making, thermometer and barometer making, gilding in which a mercurial gold amalgam is used, manufacture of electric metres and lamps where mercurial pumps are used to create a vacuum, felt hat and fur dressing in which acid nitrate of mercury is used, etc.

The symptoms of mercurial poisoning are anæmia, swollen and spongy gums with salivation, loosening and falling out of teeth, fœtid breath, diarrhœa, muscular tremors and paralysis.

The preventive measures are to keep mercury covered as much as possible so that its vapours may not be diffused, to keep the mouth and teeth clean, and to have carious teeth removed or filled in. The floor of the workshop should

be constructed in such a way as might render easy the collection of spilt mercury. Ammoniacal vapours may be diffused in the workshop when the workmen are temporarily away.

Arsenic Poisoning.—Scheele's green, a compound of arsenic, is used in making wall papers, artificial flowers, carpets and curtains. Hence persons employed in the manufacture of these articles, and those who cure and mount skins of animals, suffer from arsenic poisoning; the chief symptoms being painful rashes, sore eyes, vomiting, diarrhœa, painful neuritis and anæmia. Wall papers should not be used in rooms, as particles of the paint are liable to be easily detached, specially in a tropical clime, and on account of their fineness are likely to contaminate the air. The use of arsenical colours and dyes should also be minimized as far as possible. Arsenic works should have suitable condensing chambers and should be adequately ventilated. The workmen should observe personal cleanliness and should never take their meals in the work-rooms. Water containing waste arsenic of the factories must not be allowed to be discharged into a lake or stream.

Brass Founders' Ague.—Brass founders suffer from bronchitis, asthma and a disease called "brass founders' ague" owing to inhalation of the fine metallic particles of zinc oxide, as brass is an alloy of zinc and copper. People suffering from these complaints should drink a lot of milk, and occasionally adopt means to induce free vomiting. There should be sufficient ventilation in brass factories for the escape of noxious fumes and dust. Females should not be allowed to work in these factories.

Chromate Poisoning.—Persons engaged in the manufacture of chromate and bichromate of potassium, and exposed to the dust are apt to suffer from destructive ulceration of the nasal septum. To prevent this the workers should use nasal plugs or paint the septum with paraffin,

Tobacco Poisoning.—Persons working in the manufacture of tobacco suffer from nausea, giddiness and irritation of the eyes, but they soon become able to tolerate the smell of the tobacco fumes.

Anthrax.—Anthrax or wool sorter's disease is a dangerous form of blood poisoning, and occurs among persons employed in those industries which deal with wool, cattle hairs, hides and skins.

Preventive Measures.—Bales of wool or hair must be opened after being immersed in water, or over an efficient opening board where an exhaust fan will abstract all dust. Rooms used for wool sorting, etc., should be provided with suitable exhaust fans, and the floors of these rooms should be sprinkled daily with a disinfecting solution and swept immediately afterwards. The walls and ceilings should be limewashed at least once a year, and cleansed at least once a month. The refuse from wool sorting, carding and other rooms should be collected in proper receptacles and should be burned. Persons having cuts, wounds or abrasions on the body should not be allowed to work. There should be a separate accommodation for washing and taking meals. The International Labour Conference has suggested that arrangement should be made for the disinfection of wool infected with anthrax either in the country exporting such wool, or if this is not possible, at the port of entry in the country importing such wool.

Wool may be disinfected by first washing it in an alkaline solution and then treating it with a 5 per cent. formaline solution. Hair may be disinfected with steam under pressure.

CHAPTER VI.

OFFENSIVE TRADES.

THE offensive trades are those that chiefly deal with animal matters. These give rise to offensive odours, and may become nuisances, especially if carried on in the midst of towns and cities. As a safeguard against these nuisances many municipalities have framed bye-laws for the proper location and carrying on of these trades.

The chief of these trades which are carried out in India are keeping and slaughtering of animals, blood and bone boiling, gut scraping, fat melting, tanning and keeping of brick and lime kilns.

Keeping of Animals.—Animals, such as horses, cows, buffaloes, goats, pigs and even poultry, are generally herded together on the ground floor of dwelling houses or in badly constructed stables too near the populated locality. Hence they are a source of nuisance to the inhabitants of the house and of the neighbourhood owing to the decomposition of food, and soakage of urine and excremental matter into the ground. The collections of filth and litter also serve as a breeding place for flies and a haunt for rats.

To prevent these nuisances the stables for keeping animals should be constructed at a distance of at least 100 feet from dwelling houses, and should have an open space of 15 feet in width all round them. The height of these stables should not be less than 12 feet, and their cubic capacity should be such as to allow a superficial area of 12 feet by 6 feet for each horse and of 12 feet by 4 feet for each cattle, exclusive of space taken up by any manger or drains. The floor should be one foot higher than the mean level of the surrounding open space, should be well cemented and sloped so as to prevent soakage of urine or other filth in the ground and communicate with the receptacle for urine by a drain. There should be a separate paved space

in the stable, 1/12th of its floor area, for washing animals. The paved space and the stable floor should be washed and cleansed twice a day. Ridge ventilation with a ground-level inlet for fresh air at the head of each stall is necessary.

Dung, filth, sweepings or other offensive refuse should not be kept near any source of water used for potable or other domestic purposes so as to pollute it, but must be kept in suitable and closed receptacles made of masonry so as to prevent the escape of their contents or their soakage into the ground or into the wall of any building. These receptacles should have an aggregate capacity in proportion to the number of animals stabled, 1½ cubic feet of space being sufficient for each animal. They should then be emptied at such places as are fixed by the municipality for deposit of dung, etc. Hay, straw and grass should never be stored on the premises in a greater quantity than sufficient to last the animals for four days. Separate places away from human habitation must be assigned for storing them. Filtered water or water ordinarily used for domestic purposes should be supplied to the animals. Attendants and grooms should never be allowed to live in any part of the stable or in the loft.

Piggeries are a greater source of nuisance owing to the offensive odour coming from the sties in which the animals are kept, and from the sour and fermenting food with which they are fed. It is, therefore, essential that pigsties should be located at a distance of at least 100 feet from any dwelling house in urban districts. They should have a smooth, hard, impervious floor of concrete or Indian patent stone, properly sloped and provided with channels leading to a gully, which discharges into a drain or cesspool. The walls should be painted with cement on the inside or made of stone, so that they can be easily washed. The windows should be placed in the opposite walls for ventilation and lighting. The sties should also be provided with a roof. The food should be kept in impervious vessels with closely-fitting lids, and the sties should be swept out and cleansed daily.

Slaughtering of Animals.—To avoid nuisances arising from slaughtering of animals a slaughter yard should be outside the town, and should not be located on a low-lying land ; under no circumstances should it be situated within 100 feet of any dwelling house. It should be surrounded by a high compound wall on all sides, and the size should be sufficient to allow an open space at least 20 feet wide around the buildings. In addition to the slaughter-house proper, the yard should contain the following buildings :—

1. The cattle yard, where the cattle to be slaughtered may be collected for sale. This yard should be turfed, and proper arrangement should be made for removing dung and other refuse.
2. The lairs, where animals can be kept previous to slaughtering. These lairs should be properly paved, drained and ventilated. No habitable room should be constructed over any of them.
3. The inspection shed, where animals can be examined medically. This should be furnished with a well-equipped laboratory.
4. The offal and manure house, where the boiling of blood, preparation of manure, etc., may be carried out.
5. The cooling room.
6. The boiler house.
7. The incinerator.
8. The refrigerator and sterilizer, if possible.
9. Latrines and urinals for butchers.
10. The office for an inspecting officer.

The area required for the construction of these buildings varies with the number of the inhabitants of a town, 6½ square feet per head being necessary for towns having a population of 3,000 inhabitants, 5½ square feet per head for towns with a population of 3,000 to 5,000 inhabitants, 4½ square feet per head for towns with a population of 5,000 to 7,000, 4 square feet per head for towns of 7,000 and more, 3½ square feet per head for towns of 7,000 to 10,000 population and 2½ square feet over this number.

Slaughter-house (Abattoir).—To control the inspection of animals and prevent the slaughtering of diseased animals, all the animals intended for food should be slaughtered in a public slaughter-house, and not in the premises of private individuals, except on religious festivals, when the people might do so with the sanction of the authorities. In this case the earth and ashes ought to be spread in a thick layer upon the ground at the place of sacrifice so as to absorb the blood and prevent it from soaking into the ground.

Slaughter-houses are of two patterns, *viz.*, (1) the French or separate system and (2) the German or block system. In the French system each butcher is provided with a separate room to kill animals. These rooms open at one end into a central passage and at the other directly outside the slaughter-house. This system is more suitable to India, as in many large towns butchers and salesmen are different persons. In the German system all the buildings of a slaughter-house are under one roof, or are connected to it by covered passages. This is not quite suitable for India as there will be no free space around the building.

The slaughter-house should be so constructed that the slaughtering of animals should be visible to very few, and the noises of cattle audible to a very small circle. The slaughter-house should be provided with an adequate water-supply. It should be properly ventilated and lighted by doors, windows and sky-lights. The doors and windows should be provided with wire netting or better still with automatically working "fly-proof shutters." The floor of the slaughter-house should be made of impervious material (asphalt over concrete), and should be sufficiently strong so as not to crack or break by the falling of heavy objects or with the stamping of animals, and should be laid with proper slope and channel towards a gully, provided with a trap to prevent emanation of gases from the drains and their penetration into the slaughter-house. The corners of the rooms should be rounded off, and the surface of the walls on the interior of the slaughter-house should be covered

with hard, smooth impervious materials to a height of at least 10 feet. The floors and the walls up to 3 feet from the floor should be thoroughly scrubbed and washed within 3 hours after slaughtering.

No room or loft should be constructed over the slaughter-house. Urinals and latrines for the use of the butchers should be quite detached and at some distance from the slaughter-house. It should also not be connected with any stable.

Blood manure, garbage, and other refuse should be collected in clean vessels made of non-absorbent materials and provided with air-tight lids, soon after animals are slaughtered.

The refuse including all skins, fat and offal must be removed within 24 hours. No dogs should be kept in the slaughter-house, nor any other animals unless intended for slaughter.

Markets.—These are the places where grain, condiments, fruit, vegetables, meat, fish, etc., intended for human food are sold. These markets are either private or public. The private markets should be closed, unless they have been constructed on sanitary lines. Both the private and public markets must be under the control of the municipality, and must be under the inspection and general superintendence of its health officer or his assistant.

The public market should be situated on the main road, if possible, and within easy reach of the people for whom it is constructed. It should be so constructed as to face the main road, and the condiment or grain bazaars should also face the road and not the inside of the market. Besides the main entrance facing the road, there should be two more small entrances at each end of the market enclosure. Very often the market is partitioned into two enclosures, the first enclosure is provided with stalls for selling vegetables and fruit, and the second enclosure which is on the back of the first and separated from it by an iron gate is provided with stalls for selling meat, beef and fish. The entrance for this enclosure must be from the back of the road and under no

circumstance should be through the first enclosure. However it is preferable to have vegetable markets quite separate and situated on different sites, especially in those towns and cities, where a large number of the population is strictly vegetarian.

The rooms used for storing grain or condiment should be provided with removable plank shutters and a ventilator protected by a fine wire-gauze netting in the back wall. The roof should also have a ventilator covered with a wire-gauze netting. The floor should be paved with stone slabs with concrete underneath, and the walls should be built of masonry. To further render the room rat-proof the top and bottom of the plank shutters should be covered with zinc sheets, 9 inches wide. In front of the store room there should be a display platform and in front of this platform a covered verandah should be constructed for buyers.

The vegetable market should have several stalls, each consisting of a platform at least 6 feet by 6 inches for each stall-holder and a store room at least 8 feet 6 inches by 6 feet for storing fruits or vegetables over night. This room should be well-ventilated.

The meat market should have separate stalls for selling meat, beef and fish to suit the religious susceptibilities of the community. Each stall should consist of a passage 6 feet wide for buyers and a platform 6 feet long and 6 feet wide for the display of meat or beef, and a platform 5 feet by 3 feet for the display of fish. An iron rod with chains and hooks to suspend carcasses should be fixed in the tie beam. The platform should be covered with stone slabs, and should only project 9 inches above the floor level. Removable chopping blocks should be provided for each platform, so that they can be well scraped and cleaned. The seller should sit behind the platform.

There should be adequate arrangement for water-supply and drainage. The water-supply should be from the main pipe. In absence of a filtered water-supply, raised cisterns should be provided, which can be filled by a pump attached to

a well, so that the water may be supplied to the market under pressure. The vegetable, mutton, beef and fish stalls should be flushed out daily with a hose attached to a hydrant provided to each stall.

Each stall should be surrounded with an open *pacca* drain, which should discharge into a municipal drain outside the market on the nearest road. The garbage and rubbish should be daily collected into closely-fitting vessels, and should be removed twice a day. For the convenience of those that attend the market urinals and latrines should be located at a suitable distance from the stalls. If these are not on the water carriage system, they must be properly cleaned at least twice a day.

Blood Boiling.—Municipal contractors collect the fresh blood at slaughter-houses, and boil it to a thick consistence before it is used as manure, or as sugar refiner. The dried powder is also used for preparing blood albumin and Turkey red pigment.

The blood should be collected and stored in clean and air-tight vessels. The boiling of the blood should be carried out in properly constructed sheds, where suitable furnace arrangements should be made for the discharge of the vaporous products through shafts or funnels constructed well above the level of the habitable buildings in the vicinity.

Bone Boiling.—The bones, hoofs and hide trimmings are collected from slaughter-houses, and are boiled together to prepare gelatine, glue and fat. The bones are then used for manufacturing the handles of knives, forks, etc., or they are crushed and mixed with sulphuric acid to manufacture superphosphate manure. To prevent the offensive gases emanating during the process of boiling the bones should be boiled in steam-jacketed pans, and the furnace flue should be connected with a large hood by means of a pipe so as to collect the emanating vapours from the pans, which can be carried away to a considerable height by means of a tall chimney. To

prevent the fumes arising from the steaming bones, cold water should be applied to them, as soon as they are taken out of the boiling pans. The scutch or débris left in the boiling pans should be removed from the premises as soon as possible, as it is a great source of nuisance. Fresh as well as recently boiled bones should be dried, and treated with lime, before they are stored, nor should they be stacked in piles.

Gut Scraping.—The process for manufacturing sausage skins and catgut is very offensive. They are prepared from the small intestines of pigs and sheep. The intestines are cleansed and soaked in salt and water for a few days to soften, and are then scraped with a wedge-shaped piece of wood, until a little of the muscular coat and the peritoneal covering are left. The premises where gut scraping is carried out should be properly ventilated and lighted. The floor of the premises should be made of concrete, properly sloped and drained. The inner surface of the walls should be smooth, and made of some such impervious material as Indian patent stone up to a height of at least 6 feet. The tables used for scraping the guts should be made of stone or preferably marble. The guts should not be stored in wooden tubs, but in closed receptacles made of some impermeable material. The waste liquors should be treated with chlorine or some other disinfectant before they are discharged into a drain.

Fat Melting.—This is carried out for preparing candles, soaps, leather dressings and grease for lubricating machinery. The fats to be melted are derived from beef, mutton, pork, kitchen waste, etc. These are melted over open fires, or free steam either with or without sulphuric acid and in steam-jacketed pans. If the fat is melted over an open fire, the heat should be kept at a very low temperature as far as possible, and suitable arrangement should be made for carrying away the obnoxious fumes. This process should never be carried out in the vicinity of a thickly populated locality. From a sanitary point of view the two latter methods of

melting the fat are very good, inasmuch as the emanating fumes are collected and burned, and the fat is received into clean metal vessels.

Tanning.—Tanning of hides is usually carried out in the same premises where fell mongering and leather dressing are done. A fell monger is one who receives the fresh or old skins of sheep and prepares them for the leather dresser. The fresh skins are cleared of dirt by beating them with sticks, and are then soaked in water. Afterwards they are treated with lime, and hung up until the wool becomes loose and easily detachable. After the wool is removed, the skins are known as pelts, which are cast into a pit containing milk of lime, until they reach the leather dresser.

The old skins are first soaked for a few hours in water to soften, and then are hung up until putrefaction has rendered the wool loose, so that it can be easily detached. The other process is the same as in fresh skins.

The leather dresser converts the pelts into leathers of various kinds by treating them with fatty and other matters. The tanner tans the skins by means of oak bark, mimosa, etc., and thus the putrescible hides are rendered non-putrescible. Previous to tanning the skins are softened by soaking into a solution containing dogs' dung.

All the above-mentioned processes are very offensive. Hence tanneries should never be allowed in the neighbourhood of a thickly populated locality. The buildings should be enclosed by a compound wall at least 6 feet high. The floor should be impervious, properly sloped and drained. The inner surface of the walls should be cemented to a height of about 8 feet. Each pit or vat should be covered with a closely-fitting lid except when the hides are soaking in it. All the refuse from the pit should be removed every day in a closed vessel. All the hides spread out for drying should be covered with grass or straw or such other material as would prevent the emission of stench.

Brick or Lime Kilns.—Organic effluvia, carbon dioxide, carbon monoxide, sulphur dioxide and hydrogen sulphide are given off from these kilns. They should be located outside the town. Dung, filth, sweepings or any kind of refuse, such as stable refuse or filthy decaying vegetable matter should not be stored in the premises. No material, which gives off any offensive smell before or after ignition should be used as fuel. The kilns should be provided with flues and lighted only at night, especially between 10 P.M. and 2 A.M. A water pipe with 100 feet of hose should always be ready within 50 feet of the kiln.

Smoke Nuisance.—Large volumes of smoke emanating from the chimneys of factories as well as from dwelling houses and mixing with the atmosphere of towns cause a serious nuisance, and certainly interfere with the comforts and health of the population. This nuisance can be prevented to a great extent by locating all the factories far away from the inhabited area and by properly constructing the furnaces, boilers and chimneys, as well as by substituting gas or electricity for coal, as far as is possible.

EFFECTS OF OFFENSIVE TRADES ON HEALTH.

It is very difficult to state how far the smells emanating from offensive trades affect the health of the individuals, but they indirectly injure the health, inasmuch as they will prevent the windows from being kept open and thus interfere with the proper ventilation of the houses. Besides the continuous inhalation of the offensive gases emanating through improper storage of raw materials and boiling them in open vessels without suitable furnace and chimney arrangements for the discharge of the vaporous products through shafts or funnels constructed well above the level of the neighbouring dwellings causes anorexia, vomiting and diarrhœa, lowers the general vitality and thus renders the people more susceptible to attacks of infectious diseases. The people employed in these trades appear to be less affected than the people living in the neighbourhood.

CHAPTER VII.

SOILS AND DWELLING HOUSES.

SOILS.

SOIL is derived from the gradual disintegration of rocks through various ages and the remains of vegetable and animal matter.

It is for the sake of convenience divided into two parts, *viz.*, the upper or surface soil varying from a few inches to several feet in depth and containing partly inorganic and partly decayed animal and vegetable matter constitu· what is known as mould or "humus," and the subsoil hours ier layer extending some hundreds of fee in depth and composed of inorganic materials derived from the underlying primitive rocks broken through the corroding action of gases, water, roots of trees, etc.

Influence of Soil on Health.—The health of people living in any locality is supposed to be influenced by the physical characteristics of the soil on which the dwellings are built. Some of these are surface configuration, vegetation, micro-organisms, air and water in the soil, and subsoil heat and temperature.

Surface Configuration.—The chief points to be considered in this connection are the relative extent of hilly and flat lands, the direction and height of the hills together with the angle of their slopes, the nature of the valleys with reference to their size and depth, and the chief watersheds showing the direction and discharge of the water courses.

Vegetation.—Vegetation exerts a great influence on the healthiness of a soil. In cold countries the soil is cold and moist owing to the growth of vegetation which prevents the penetration of the sun's rays, and thus does not allow of

rapid evaporation from the ground. On the contrary in tropical countries vegetation makes the ground cool by affording a shade, by obstructing the sun's rays and by aiding evaporation.

Micro-organisms in the Soil.—Micro-organisms are always present more in the superficial layers than in the deeper ones, and they are more numerous if the soil is richer and more polluted with organic matter. They help in nitrifying organic matter, and thus convert it into nitrates and nitrites, which supply nourishment to the plants. These processes of putrefaction and fermentation cannot be carried out in the absence of organic matter, oxygen warmth and moisture. These micro-organisms are called saprophytic, as they do not produce disease in man; however, certain pathogenic micro-organisms are also found in the soil, the chief of which are the bacilli of tetanus, anthrax, enteric fever, cholera and malignant œdema.

Air in the Soil.—Air is always present in all the soils, including even the hardest rocks, and is known as ground or subsoil air. Its composition is very much the same as that of the atmospheric air, though the amount of CO_2 preponderates in it on account of the process of putrefaction of organic matter taking place constantly through the action of bacteria present in it. Its amount varies from 2.4 to 9.74 per thousand. Its quantity varies with the proportion of organic matter, rainfall, as also the temperature and depth of the soil. Besides CO_2, this air contains a large amount of moisture, ammonia, marsh gas, carburetted hydrogen, sulphuretted hydrogen and nitric acid. Its composition has, however, been known to vary on account of its constant movement. This movement is brought about (*a*) by the law of diffusion of gases, (*b*) by the action of winds, (*c*) by rainfall, (*d*) by variations in temperature and barometric pressure, and (*e*) by fluctuations in the level of the ground water. Foul air in the soil derived from broken drains or cesspools may be sucked through a considerable distance into a house, when the air

inside it happens to be warmer and lighter owing to fireplaces, or when the doors are closed. To prevent suction of such foul air into a dwelling house the basement should be cemented or concreted, or the house should be built on arches.

Water in the Soil.—The water in the soil consists to some extent of the amount of moisture present in its interstices, but largely of ground water present in all soils at varying depths as a more or less continuous sheet.

The moisture of the soil is derived from rainfall, movements of the ground water, and from capillary attraction and evaporation of the subsoil water through its superficial porous strata, but some of it is always lost by evaporation from the surface and through vegetation. The amount of moisture present also depends on the nature of the soil, For instance, clay soils may retain as much as 20 per cent., chalk 12 to 16, humus 40 to 60, and granite ½ to 4 per cent.

Moist or damp soils can be rendered dry by draining them, opening the outflow and by clearing out clogged water-courses.

The ground or subsoil water is found below the surface of the soil at a depth varying from a few inches to a hundred feet or more. The difference in its level depends on the porosity or compactness of the soil, the amount of rainfall and the depth and distance from the surface of impervious strata. The ground water has a tendency to flow towards lakes, springs, rivers or the sea.

Soil Heat and Temperature.—The heat of the soil varies with the geological formation and the atmospheric temperature; but this variation is not commonly noticeable below four feet from the surface. The temperature of a soil depends upon its power of absorbing, retaining or radiating heat.

The sandy and dry porous soil becomes rapidly warm, and retains heat for a long time. The absorption and radiation of heat by moist soils, for instance, of a clay

composition, are comparatively slow, as the presence of moisture in them retards both the processes. Such are, therefore, known as "cold soils." The radiating power of the soils is influenced by the colour of the surface and the thickness and growth of vegetation. The surface soil is, as a rule, warmer by day and colder by night than the surrounding air.

Classification of Soils.—From the health point of view those soils, whose geological formations favour slope, dryness, warmth and a moderate amount of vegetation, may be generally regarded as the healthiest. The soils are, however, usually classified into :—

1. **Sandy Soils.**—These consist almost entirely of sand. They are healthy, if pure and dry, but are unhealthy, when the level of the subsoil water is high and organic impurities are present. Sandy soils in the Punjab contain much magnesium carbonate and lime salts, as well as salts of the alkalies. Drinking water may, therefore, contain large quantities of sodium chloride and carbonate, and also iron, lime and magnesium salts.[1]

2. **Clayey Soils.**—These are stiff, damp and cold soils, and are composed mainly of silicate of alumina. They are generally condemned.

3. **Alluvial Soils.**—These include marls (a mixture of sand, clay and lime), loams (a mixture of sand, clay and organic matter), and humus (chiefly containing the products of vegetable decomposition). They are practically always damp, and unhealthy, as they retain water owing to want of slope and favour the growth of rank vegetation. These characteristics are found in the deltas of large rivers.

4. **Granitic, Metamorphic and Trap Rocks.**—These are generally dry and healthy, as owing to natural

1. Notter and Firth, Theory and Practice of Hygiene, Ed. III., 1908, p. 403.

slopes they do not allow water to collect. Hence vegetation is very little, and marshes are not common. Weathered rocks become disintegrated, absorb moisture, and become unhealthy.

5. **Chalk and Sandstone.**—These are healthy soils, if they are not mixed with or based on clay.

6. **Gravelly Soils.**—These are dry and healthy, except in hollows where the ground water is at a high level. Gravel hillocks are the healthiest of all sites. The water is, as a rule, pure.

7. **Limestone and Magnesium Limestone Soils.**—These are dry and healthy, as water passes quickly owing to great natural slopes. Marshes may, however, occur at any height.

Diseases attributable to the Soil.—It is true that the saprophytic micro-organisms being stronger do not allow the delicate pathogenic germs to grow indefinitely in the soil on the principle of "the survival of the fittest." Though doubtless some pathogenic germs are met with in the soil and are liable to exert the pathologic action through the subsoil air or water. The diseases caused by these germs are anthrax, tetanus, malignant œdema, enteric fever and cholera. It is very likely that the germs of cholera and enteric fever enter the soil from infected excretions from leaking cesspools and drains, and thus pollute the ground water.

Hookworm disease is closely associated with a moist and sandy soil. The eggs of Ankylostoma duodenalis, when deposited in fæcal matter upon such soil find favourable conditions for development, and infect susceptible persons. In a similar manner most of the intestinal parasites, such as Tænia solium, Ascaris lumbricoides, etc., are deposited with the fæces in the soil, and reinfect man during one of the stages of their development.

Malaria and yellow fever are generally met with in low lying marshy districts, for the mosquitoes breed abundantly there owing to their being water-logged.

The vitality of persons living in houses erected on damp soils is lowered very much by constant inhalation of ground air polluted with emanations arising from decomposition of organic matter present in the subsoil, and they become particularly predisposed to attacks of phthisis, diphtheria, measles, whooping cough or any other infectious disease.

Rheumatism, catarrh and neuralgia are also liable to be caused by damp soil.

DWELLING HOUSES.

Houses should be built on a dry porous soil, such as sandstone, gravel, limestone or chalk, which allow of free drainage, and are not likely to get water-logged. Clayey soils should particularly be avoided in selecting a site for them The other important points that should be taken into consideration in the matter of selection of a site are those referring to its openness, the purity of air and its surface drainage. Valleys, deep hollows, ravines and *nullahs* are particularly unsuitable on account of their containing a large amount of stagnant air polluted through the putrefaction of decayed organic matter.

The ideal sites for a dwelling house are the summits or sides of hills, or what are known as "saddle backs," provided that they are well shaded. In the plains, on the other hand, houses should be built, as far as possible, on elevated sites with a gentle slope allowing easy drainage of rain and subsoil water. They should not, however, be built in the vicinity of waste jungles and shallow *katcha* tanks, *jhils* or other collections of stagnant water. The neighbourhood of sewage farms, factories, graveyards and cultivated fields is also undesirable.

In cities and towns, houses should never be built on "made soils" which are formed by filling up pits and hollows by household refuse and rubbish.

The ground water should not be nearer the surface than 10 feet, and not subject to sudden or great fluctuations.

Moreover, they should be protected against the variations of prevailing winds by means of a sparsely placed vegetation round them.

Dwelling houses should also have some open space all round, if possible, equivalent in superficial area to their height and width which will allow a free ventilation and excess of light. The height of these houses should not be more than the width of the street, on which their frontage abuts. At any rate the height should never exceed 70 feet, and the roof should never make an angle greater than 45 degrees with the frontage. They should also be so located facing east or south-east, that they may have the advantage of direct sunlight in the morning and a protection against it towards evening. Bed-rooms should, as far as possible, be placed on the second floor and made to face north-east.

Besides, they should have a few feet of ground concreted, metalled or paved all round, and next to them preferably a plot with green grass kept well mowed.

If there is much subsoil water, it should be drained separately by earthenware pipes having no connection with the house drains.

It is also necessary to have a good supply of potable water near dwelling houses in country districts in the shape of properly constructed wells protected from all sources of contamination.

Foundations.—The foundations must be well laid so as to support the weight of the building. They should be covered with an impervious layer of concrete, cement or stone, at least eighteen inches in thickness and extending six inches beyond the base or footing of the wall on each side. The house should have a plinth well raised above the ground-level so as to exclude damp and ground air. Raising the house on

pillars and arches in addition affects this even more thoroughly by allowing free ventilation underneath.

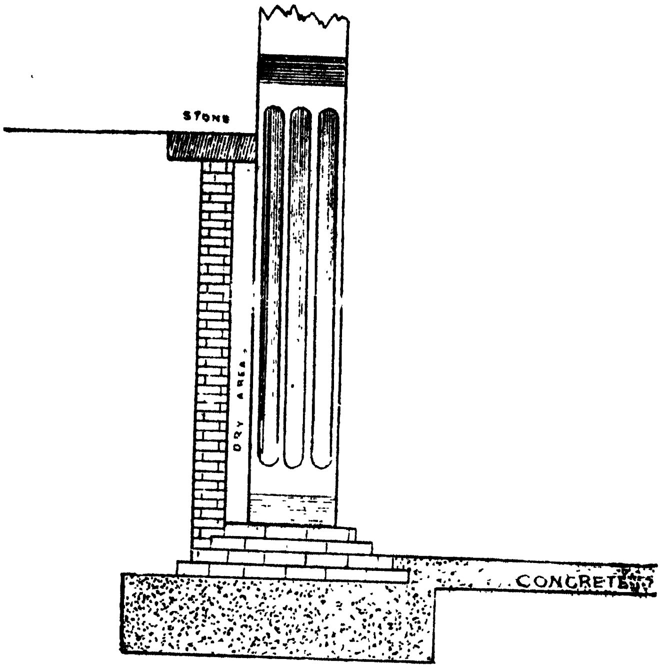

Fig. 11—Damp-proof course.

Walls.—Walls are ordinarily constructed of bricks, stone or wood. Bricks are porous and absorb water very freely, and also allow air to pass through. It is, therefore, better to cover the bricks on either side with plaster which should be limewashed at least once a year. Again, a short distance above the ground-level, a layer of impervious material should be interposed into the structure of the wall so as to prevent moisture arising from the ground by capillary attraction and thus saturating the walls. This layer is known as the *damp-proof course*, and it may consist of stone slabs laid

in cement and pointed with cement, asphalt, glazed bricks laid in cement, slates in cement or sheet lead.

Walls in India are generally two or three times thicker than in England. In the case of single-storeyed buildings they are usually 2 bricks thick, and those of double-storeyed buildings are 2½ or 3 bricks thick at the ground floor, and 1½ or 2 bricks thick at the first floor.

Hygienically they should have two layers with an intervening space to prevent their becoming too hot or too cold according to the season of the year. The top of this air space should always be covered by glazed tiles or stone to make it thoroughly non-conducting.

Doors and Windows.—Every living room should have at least a door and a window. The door should not be less than 6 feet by 3 feet. The window must open on to the external air, and must have an area equal to one-tenth of the superficial area of the room.

Floors.—The floors of dwelling houses should be made of an impervious material, which can be easily kept clean. The materials that are ordinarily used in India are rammed concrete plastered with cement, stone, bricks, tiles and marble. Seasoned teak boards closely jointed together are rarely used in India.

Roofs.—Roofs are either made flat or sloping, but in the case of flat roofs they should, however, be sufficiently inclined for free downward flow of rain water. In the construction of sloping roofs, tiles, thatch or corrugated iron sheets are used. Even in constructing roofs, double layers with an intervening space should also be provided as for the supporting walls. Thatched roofs are cool and dry, but they have the disadvantage of commonly sheltering birds, snakes and insects. besides their being exposed to the serious danger of fire. Roofs constructed of corrugated iron sheets become very hot during the summer.

Roofs should be provided with narrow channels all round to receive collections of water and provided with rain pipes at intervals to allow of an immediate discharge of them down below. In placing the rain pipes care should be taken that they are not placed directly against the walls, to prevent their absorbing moisture in the event of a breakage or leak occurring

CHAPTER VIII.

HOSPITALS.

GENERAL HOSPITALS.

Site.—The grounds on which a general hospital has to be constructed should be elevated and well drained, and the site should be easily accessible to the population for whose benefit it is intended. It should, therefore, be on or near a main road and in a healthy situation. Its area should be sufficiently large so as to provide for the future extensions as well as for present requirements. Ordinarily one acre of land should be allowed for every twenty beds, but in no case should it be more than forty beds. It is preferable to have a one-storeyed hospital, but from a point of economy of space a double-storeyed hospital may be erected, in which case, the clinical room, the X-ray department, offices, etc., should be on the ground floor, and the wards on the second storey.

The hospital building should ordinarily be divided into an administrative block, an out-patient department and an in-patient department.

Administrative Block.—This is meant for housing the medical officer, the subordinate staff and accommodating the kitchen, store-room, etc. The nurses' quarters are usually built separately. Raised paths from one building to another should be provided. The block should be larger than is necessary at the time, in view of the probable extension of the hospital in the future. The laundry should be situated at some distance from this block. It should be provided with tanks for soaking soiled clothes, and sloping slabs or stones for washing purposes. There should be two small rooms made of corrugated iron and provided with doors, one of which will be used for temporarily storing soiled clothes, and the other for keeping clean clothes. An open corrugated iron or other shed

is also necessary for drying clothes during the rains and for ironing them.

Out-Patient Department.—This should consist of a prescribing room, a dispensary and separate waiting places for males and females. A table should be placed in a side room behind a screen in a well-lighted place for the examination of patients. The dressing places for males and females should also be separate and screened off. In large towns it is also necessary to provide an operation room for performing minor operations requiring the patients to be anæsthetised. The steps of the out-patient building should be constructed of brick in lime mortar and the treads should be paved with stone slabs painted with Portland cement, or they may be made of clinker brick on edge, or of brick rendered with Portland cement or 6 in. by 6 in. tiles laid in Portland cement. The floor should be paved with any suitable class of patent stone on 4 inches of concrete. The interior of all rooms should be painted with Paripan or other suitable, white, glossy, washable paint or a coat of Portland cement, ½ inch thick, but the operation room should be faced with white glazed tiled dado for a height of at least 5 feet from the floor and above this plastered with cement, ½ inch thick, and painted with Paripan. The exterior of all rooms should be plastered throughout with two coats of lime mortar.

In-Patient Department.—The wards of a general hospital should be built on the pavilion system with a small verandah on each side. The verandah on both sides keeps them cool and shady. They should be oblong, and should have their long axis directed from north to south, and should be separated from each other by a distance not less than twice their height. There should be separate wards for males and females, and for medical and surgical cases.

Each ward should be from 24 to 30 feet wide, and 12 to 15 feet high, and the length should be such as would allow

120 square feet of floor space to each patient and 1,200 cubic feet of air space especially where students and nurses are required to work in the wards. The minimum floor space approved by the Inspector-General of Civil Hospitals of the United Provinces of Agra and Oudh is 60 square feet and 810 cubic feet of space per patient. The minimum floor space allowed in a jail hospital in the United Provinces is 54 square feet and 900 cubic feet of capacity for each patient. The windows should be opposite to each other, should have an area of one square foot for every 70 cubic feet of ward space and should reach within one foot of the ceiling. When within reach all windows should be pivoted at top and bottom. They must be covered by fine mesh wire gauze netting to keep away flies and mosquitoes.

The wards are ordinarily ventilated by keeping the windows open so as to allow cross-ventilation, but an arrangement should be made to bring in fresh air by means of tubes and to remove the foul air by constructing clerestory windows or openings in the ceiling especially for the cold and rainy seasons, when the windows are kept closed. The inlets in the form of tubes should be placed under the beds to prevent draughts.

The number of beds should be from 24 to 32 in one ward, but the main ward may contain 40 beds. The beds should be arranged with their heads to the wall facing into the ward, so that there should be a wide passage of about 11 feet between the two rows of beds. Each bed should be placed in an intervening space between two neighbouring windows, which should be at least a foot wider than the bed. Two beds may be placed in one space, if they can be so arranged as to have a distance of at least 3 feet between them.

In northern India it would be necessary to provide for the heating of wards during winter. This can be carried out by open fireplaces, ventilating stoves, or hot-water pipes. Cooling of the wards during summer may be carried out to

some extent by electric fans and *khas khas tatties* kept wet by water being sprinkled at regular intervals.

Megaw[1] recommends the following arrangement for cooling the wards during summer :—

The ward should be built with double walls, double roof and double windows, which should close so tightly that the ward would be practically air-tight except for the air inlet and outlet which are provided for. The doors would be as few as possible and these would be arranged so as to avoid any appreciable entry of outside air when they are opened. In the end of the ward which faces the prevailing wind there will be fitted a *khas khas* screen, kept moist by water dripping from a perforated pipe connected with a cistern. Air will be sucked through the moistened screen and delivered into the ward by a large fan, preferably of the "Sirocco" type. In front of this fan there will be a screen of wire gauze whose mesh and shape will be designed so as to ensure that the air will be discharged into the ward at a uniform velocity from every part of the screen. At the other end of the ward there will be fitted an exhaust fan working at the same speed as the inlet air fan; in this way there will be a slowly moving column of cool fresh air in the ward. During the cold weather the windows would be opened wide or the verandahs could be used instead of the wards. In extremely cold weather the air of the ward could be heated by replacing the *khas khas* screen with pipes containing hot air or hot water.

Separate bath-rooms and water closets or latrines for males and females should be provided in a corner away from the main ward, but connected to it by means of a covered passage, 10 feet in length.

The nurses' room, or what is commonly known as the duty room, should be at the near corner of the main ward, and should have a window overlooking it.

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1. Indian Medical Gazette, Nov. 1924, p. 574.

The operating theatre must be at such a place, where there is sufficient light and the least danger of dust. Big windows with ground glass panes should be placed in the northern and southern walls, so that, there would be enough light in the room, but no direct sunshine on the patient or the operator. No one should be allowed to enter the operating theatre without wearing an overall. There should be a gallery with a staircase leading on to the outside verandah, by which the students, not on duty, can enter and watch the operations.

The anæsthetic room should open into the operating theatre on one side, and into a well-equipped sterilising room on the other.

A site for constructing a mortuary and a post-mortem room should be chosen, which is not objectionably in close proximity to the wards.

An observation ward should be constructed quite separate from the general hospital, and should be treated as a contagious diseases hospital. Doubtful cases as well as cases of cholera, tetanus, etc., should be treated in this ward.

It is desirable to have private wards for the convenience of middle-class people, who observe the *pardah* system, and who still want to be treated in the hospital. Each ward should be a perfect unit by itself, inasmuch as it should have a kitchen, a bath-room, a latrine and one more room, besides the ward itself. These wards may be constructed in one block, but separated by a partition wall, and removed from the general wards.

Floors.—The floors should, wherever possible, be laid with a gentle slope in one direction towards channels along one wall of the wards, or in the case of verandahs, towards the outside of the verandah to facilitate washing with water and disinfectants. The surfaces of all the floors must be continuous and not interrupted by the projecting door sills or thresholds. For flooring surfaces in wards, operating

theatres and mortuaries, where an impervious unjointed floor surface is desirable, Bird's Indian patent stone, marble or the Bombay Co.'s Truscan floor enamel over ½ inch Portland cement are recommended by the Madras Sanitary Board. These materials readily lend themselves to the formation of channels along the walls.

Walls.—The internal walls of the wards, operating theatres, dispensaries and mortuaries should be rendered smooth with Portland cement from floor to ceiling and painted with Paripan "glossy," or other "glossy" white washable paint. They can also be made of an impermeable material, such as tiles or glazed bricks. All the internal corners should be rounded, and there should be no crevices or ledges which will allow the collection of dust. The external wall surfaces, if built of stone, should preferably be painted with cement, and if of brick, should be plastered and white-washed.

Ceiling.—The ceiling should be cemented or white-washed. Where jack arches are used, the tie bars should be embedded in the masonry of the arches.

Doors.—The door sills must not project above the floor level. Wherever possible, wooden door sills should be avoided. Flat panels should be used, as the raised panel doors catch dust. The doors in wards, operating theatres, dispensaries and mortuaries should not be less than 4 feet 6 inches between masonry jambs, so that there should be no difficulty for the stretchers to pass in and out.

Furniture.—The furniture in the wards should be as little as is compatible with the comfort of the patients and attendants. There should be no curtains, hangings or drapery of any kind. The bedsteads should be made of iron with spring wire mattresses, and should be 6 1/2 feet long and 3 feet wide. The ordinary iron bedsteads with a durrie stretched across the poles by means of a string are very good, but they harbour bugs and lice. In the surgical wards, fracture beds

with movable boards should be provided. The other furniture should be simple and strong, made of iron, where possible. It should be so constructed as not to harbour vermin, and made to be easily cleansed.

MATERNITY HOSPITALS.

In India it is desirable that the maternity hospital should be quite separate from the general hospital, and there should be a separate establishment. It should be located near the centre of the population for whose benefit it is intended.

One unit should consist of two wards, and each ward should contain only four beds. There should be two separate delivery wards for each unit, one to be under cleaning, while the other is in use. Each unit should have a separate bath-room or scullery with plenty of water and means for disinfecting soiled clothing. The scullery and the latrine for the use of patients should be under a separate roof, but joined to the wards by a covered lobby open at both sides.

The floor space in the delivery wards should not be less than 150 square feet. It is a good plan to have a by-ward in connection with the delivery ward for the temporary care of specially exhausted cases.

The attendant's room and the store-room may be conveniently constructed at the corners of the verandah.

It is also necessary to have a waiting room for patients, and a well-lighted room for their examination.

ISOLATION HOSPITALS.

These are ordinarily known as fever hospitals in Europe, and are used for the isolation and treatment of patients suffering from small-pox, scarlet fever, diphtheria, enteric fever, cholera, plague, cerebro-spinal fever, infantile paralysis and typhus fever. These are of great value in combating the spread of infectious diseases and, must, therefore, be provided in all large towns and cities.

Site.—The site selected for building an isolation hospital should be far away from inhabited buildings, but should be easy of access. If the site is selected on the outskirts of a town or city, it should be sufficiently commodious as to provide a space of one acre for every twenty to thirty patients.

Building.—To ensure thorough isolation the hospital building should be at a distance of 40 feet from the boundary wall 6½ feet high, and should be of such a size as to roughly provide one bed for every thousand of the population, but this cannot be arbitrarily laid down as a standard, for it will depend more or less upon the characters and habits of the population, the incidence of infectious diseases and the number of diseases for which isolation is made compulsory. In India cases of plague, cholera and small-pox are generally isolated in these hospitals, but there is no compulsory isolation of even these patients.

A large infectious diseases hospital should consist of an administrative block for the medical officer, nurses, dispensary, kitchens, etc., wards for the accommodation of the sick and the accessory buildings, such as a mortuary, ambulance shed, laundry and quarters for the menial staff.

The administrative block need not be at a distance of 40 feet from the boundary wall, but should be at least this distance from the hospital wards.

Wards.—There should be separate blocks for the treatment of each disease, and each block should have two principal wards, one for males and the other for females. There should also be a special block containing at least two or three small wards to receive doubtful cases, before they are diagnosed and admitted into the principal wards. Bath-rooms and latrines should be placed in a block outside the ward, but connected with it by a cross-ventilated lobby. These blocks should be at least 40 feet apart from each other, and the same distance from the boundary wall. It is much better not to have any communication between the different blocks;

however, they might be connected at right angles to their length by a covered corridor but open on both sides.

All the wards should, as far as possible, be on the ground floor, but if a double-storeyed building has to be used to economize space, the second storey must be reserved for the treatment of convalescent patients.

The wards should be rectangular in shape, and should contain ten or twelve beds, allowing 150 to 200 square feet of floor space, and at least 12 feet of wall space per bed, and 2,000 to 2,500 cubic feet of air space per patient. The windows should be situated on both sides, and should have an area of at least 1 sq. foot to every 40 cubic feet of ward space.

The wards are usually built on the pavilion system, but the cubicle system has lately come into vogue. This system is more favourable to the patients' recovery, and to reduce the risk of secondary infections and is more suited to Indian requirements. In this system a large ward is divided into a number of small rooms by means of partitions made of glass to a height of 7 feet. Each room is well lighted, and opens on to a verandah. It contains a bed and other necessary furniture, and is large enough to allow the patient between 2,000 and 3,000 cubic feet of air space. The nurse's room is situated near the centre of the block, so that she can supervise each of the cubicles while sitting in her own room. When a bath is to be given to the patient, a portable bath is brought into the cubicle.

The floors, ceilings and the internal surfaces of the walls should be made of impermeable material so as not to hold or absorb organic effluvia. The floors should be cleansed morning and evening with a 10 per cent. solution of hypochlorite of soda.

All soiled linen and dirty dressings must at once be placed in a disinfecting solution or in air-tight boxes, and carried to the laundry. Excreta and sputa must be mixed with a disinfecting solution, and removed from the wards

at frequent intervals. They should then be mixed with solid refuse matters and burned.

Dishes, cups, spoons, etc., used by the patient should be collected and picked up by a nurse on duty with an antiseptic towel, and placed in a metal receptacle. This should then be carried to a special room, where they should be boiled and disinfected.

Basins containing disinfecting solutions should be kept on the verandah in which the doctor and the nurses should wash their hands on coming out of the ward.

The following are the regulations which must be observed in isolation hospitals :-

1. Medical officers and students should wear overalls on entering the wards, and should wash their hands on leaving.

2. Nurses must not leave the hospital premises without changing their outer clothing, which should consist of cotton material.

3. Relatives visiting the patients should wear overalls on entering the wards, and should wash their hands and faces on leaving. They should be warned not to enter any public conveyance immediately on leaving the hospital.

4. Tradesmen must not be permitted to pass beyond the boundary wall.

5. Convalescents should be given a hot bath, and their clothes disinfected before they are discharged from the hospital.

Temporary Hospitals.—Where the construction of permanent hospitals is not possible owing to the cost, necessary materials should be kept ready for erecting temporary hospitals, so that there should be no difficulty in isolating the first case, as soon as an epidemic breaks out. In India most of the infectious diseases occur at regular periods of the year ; hence there should be no difficulty in erecting such a hospital a week or two before the actual outbreak of an infectious disease.

The floors of the temporary wards should be raised at least a foot from the ground and made of concrete and

cement. The roof should be made of corrugated galvanized iron sheets, and its ridge should be used for ventilation as well as the windows. It may also be thatched with grass as a temporary measure. The walls should be made of *jhamps* or matting, which should be so arranged that they can be lifted up at the sides of the ward, so that the patients may practically live in the open air with only a roof over them. The thatched roof and the walls can be easily burnt, when the epidemic is over. Instead of matting tents can be used, but the best tents are those, in which the four sides can be well raised during the day.

SMALL-POX HOSPITALS.

In India there are no separate hospitals for the isolation and treatment of patients suffering from small-pox. They are generally removed to the isolation hospital, if one exists. But in England and other countries separate hospitals for small-pox are constructed, because small-pox cases, if admitted into a ward of the general isolation hospital, might convey the disease to other patients admitted into the hospital.

If it is necessary to erect a separate small-pox hospital, the following rules laid down by the Local Government Board of England should be observed in order to avoid all possible risk from aerial convection of infection :—

1. The site should be such as would not have within a quarter of a mile of it as a centre, either a hospital, whether for infectious diseases or not, or a work house or any similar establishment, or a population of 150 to 200 persons.

2. The site should be such as would not have within half a mile of it as a centre, a population of 500 to 600 persons, whether in one or more institutions, or in dwelling houses.

But this view is not shared by all medical men. Some are of opinion that the small-pox hospital is no danger to its next-door neighbours, if it is well screened and properly managed.

CHAPTER IX.

SCHOOL HYGIENE.

"THE impressions of childhood are deep and lasting. Hence it is necessary that they should in all respects be sound. Neatness, tidiness, cleanliness, freshness of atmosphere, punctuality, and orderliness in school, leave impressions on scholars, which are likely to have lasting effects in their after-life. The hygienic conditions of the schools should, therefore, in all cases be of a vastly higher standard than those to which the scholar is accustomed in his own home."

The School Site.—The site selected for a school should be elevated to provide for suitable drainage, and sufficiently large and open to allow the free access of pure air and light. The area of the site should, on an average, be one-fourth acre for every two hundred and fifty scholars. In its immediate vicinity there should be no depressions, hollows, tanks, rivers or watercourses. large open drains, or premises in which insanitary trades likely to affect adversely the health of scholars are carried on. To afford an easy means of access to the scholars the site should be central but removed from the noise of traffic. In large towns and cities, where a quiet site cannot be obtained, the building should be set back at least sixty feet from the main street.

The School Building.—The school building should be constructed on a plinth at least one foot above the ground, to be increased in proportion to the humidity of the soil in the area selected. If an elevated site be not available, the plinth should be raised at least two feet. The immediate surroundings to a distance of half the breadth of the building, should be properly sloped. To ensure a dry and healthy site it is necessary to have a *pacca* drain surrounding the plinth and

connected with properly sloped effluent drains, so as to lead away storm water to the general drainage of the neighbourhood.

Where the school building has to be divided into a number of class rooms, the modern tendency is to group them round a large central or assembly hall, but a better system is that in which the class rooms are placed end to end in one line and connected by means of a corridor, eight to ten feet wide, which runs along one side of the rooms. However, if it is considered necessary to have a central hall, in which all scholars can congregate together, it should [illegible]tely isolated from the class rooms, or at any rate it should be separated from them by ventilated corridors or verandahs.

The class rooms of primary schools should be on the ground floor but, if this is not practicable owing to the paucity of ground in large cities, upper storeys must be provided, but should not be more than two storeys. The stairs should, in that case, be fire proof, at least five feet wide, and the doors at their foot must open outwards.

The Educational Board of England allows ten square feet of area per scholar, but in India the class rooms should be so constructed as to provide at least twelve square feet of floor area per scholar. The rooms should be more or less oblong since lighting and supervision can be more satisfactorily carried out than in a square room. Such a class room should be thirty feet long, twenty feet broad and at least fifteen feet high.

The floor of the class room should be made of concrete, tiles or stone flagging, or it may be of brick on flat, laid on *kankar*. It is preferable to have the floor made of hard wood and polished with beeswax, but it cannot be universally adopted on account of cost. There should be no crevices in the floor, in which dust could lodge.

The interior walls of the class room should be painted or distempered to permit of regular washing, and should be

of a greenish grey colour, since this increases the brightness of the room by reflecting light rays to a greater extent than other colours. The corners formed by the junction of the walls with the floor and the ceiling should be rounded off to facilitate cleaning. Unnecessary cornices or beams, or places, on which dust can settle, should be avoided.

The cleanest and most hygienic type of a roof is that of the jack-arch type of *pacca* brick.

If, however, owing to the financial difficulties it is not possible to erect an ideal school building especially in small towns or villages, open air classes under shady trees should be held on a *pacca* platform raised at least one foot above the ground.

Cloak Rooms.—Cloak rooms are not considered to be so necessary in Indian schools as in European schools; but it is better to provide a distinct and separate room to place umbrellas and waterproofs used in the rainy season. These rooms should be well ventilated and capacious so as to allow a space of at least 150 square feet for every fifty scholars, and should be fitted with numbered pegs at a convenient height and at intervals of 12 to 15 inches, so that scholars may not exchange their caps, as ringworm of the scalp is often spread by their caps. It is desirable to have separate umbrella racks with proper drip channels.

Orientation.—The school building, if provided with only one corridor, should face north-west and south-east, and should have the corridor on the side which faces south-east so as to afford a maximum amount of sunshine and ample lighting. However, in the United Provinces of Agra and Oudh it is desirable that the school buildings especially of the high schools should face north and south so as to protect the majority of the class rooms from the hot westerly winds. Again those class rooms which are situated in the wings and whose doors face west can, if necessary, be cooled with *khas khas tatties*, if used during the hotter part of the day.

Lighting.—Light should come directly from the sky, and should be sufficient to enable a scholar with normal eye-sight to read in any part of the class room with ease small print at 12 to 16 inches from the eye. The windows should be placed on both sides of the class room, so that the angle of incidence made by the falling of the sun's rays into the room should not be less than 25°, and the angle of aperture or arc of the sky should never be less than 5° of an arc in any part of the room. But the windows giving the chief light should be on that side of the room which is to be to the left of the scholars so as to avoid shadows being thrown on the paper when the scholar is writing. Windows in front of the scholars are apt to dazzle their eyes, while those situated on their back are likely to cast a shadow on their work. Both these should, therefore, be avoided. Skylights are also unsatisfactory, and should not be used to illuminate the class room.

The windows should be wide, and not too far apart. They should reach as high as the ceiling of the room and should open directly into the external air. The glass panes should not be too much broken up by wood work. The window sills should be four feet high from the floor, and the window area should be from one-fourth to one-sixth of the superficial floor area.

Ventilation.—Natural ventilation by means of the windows is usually sufficient to maintain the purity of the air in class rooms, but artificial means may be necessary for seasons when the widows are closed. For this purpose inlets and outlets should be provided on the pattern of louvres made of stone and built into the walls like a venetian blind. The inlets should be directed obliquely upwards and from without inwards, and placed at such a level that the lowest part of the louvred area is at least two feet from the floor, to allow of the ingress of pure air. These should be protected by wire netting on the inside to prevent their being

tampered with by the scholars. The outlets should be placed higher up within one foot of the ceiling, should be directed from within outwards and upwards, and should be protected by wire netting on the outside to prevent the birds from entering and building their nests. They should also be provided with rain-protectors. To ensure thorough ventilation of the class rooms all the doors and windows should be thrown open during an interval of five minutes allowed after every period of school work. No one should be allowed to remain in the class rooms during this interval. The scholars would also be benefited by this interval, as they will have a brief but sufficient mental and physical relaxation, and will be better fitted to put their mind to the next class work.

School Furniture.—The most important articles of furniture in the class room are the seats and desks. These should be provided for each scholar separately. This plan is preferable to combined seats and desks for several scholars. The seats and desks should be of an adjustable pattern to suit the convenience of the scholars of all ages. They should be placed at a distance of 24 inches from the wall, and there should be an interval of 10 inches between the rows of seats. They should also be arranged parallel to one another and at right angles to the windows in the side wall on the left of the pupils occupying them.

The desks should not be of the box pattern as this leads to slovenly habits and the collection of undesirable odds and ends. An open shelf may, however, be provided, if desired. The desks should be from 15 inches to 18 inches broad, and should be inclined at an angle of 15 degrees for writing and 45 degrees for reading. The desk should overhang the seat by one or two inches so as to avoid stooping while writing. The height of the desk above the seat should be one-sixth of the scholar's height, *i.e.*, it should be such that when the scholar is sitting down, he can place both his forearms comfortably on the desk without raising or depressing the shoulders.

The seats should have a rounded front, should be 10 to 12 inches wide so as to give enough support to the upper parts of the thighs and should be so high that the feet of the scholars occupying them should rest square upon the floor. They should also be provided with a back, which should be hollowed out in such a way that the upper part of it may fit the concavity of the back and thus support the body in an erect posture.

Matting should not be allowed on the floor, if the seats and desks are used in the class. It simply harbours dirt.

In village primary schools, where money is the chief question, it is not necessary to provide the seats and desks, but the scholars can sit on the floor. In that case the teachers should insist that the scholars raise one knee and use it as a desk while reading and writing so that by adopting this posture the spinal curvature and undue compression of the thoracic and abdominal organs may not be produced. Moreover, in these schools, each scholar should be separately supplied with a piece of *moonj* matting or other material of this nature, and should be responsible for keeping his own mat clean. It should be renewed, when necessary.

Black boards should be dull black, not glossy, and should be provided with chalk-troughs to prevent dissemination of the chalk-dust. They must not be placed in good light. Maps should not be too glazed to be injurious to the eyesight of the scholars by looking at them for long periods.

All almirahs for books and school materials should be built into the walls to avoid the collection of dust. If this is not possible, the tops of the almirahs should be sloped to allow of easy cleaning; they should also be raised on legs at least 12 inches in height to facilitate cleaning underneath.

Cleaning of Schools.—At the end of every day's work the doors and windows of each class room should be opened wide, and the floor swept with a wet duster or with a broom after being wetted to keep down dust. Once a week the

furniture should be removed from each room, the floors and window sills should be well scrubbed with hot water and soap, and the furniture should be replaced after cleaning it thoroughly. Once in a fortnight the rooms should be thoroughly sprayed with a disinfectant, such as izal or cyllin. All waste matters should be collected and burnt, or deposited in metallic dust-bins covered with closely fitting lids, and placed out of reach of the scholars.

Water-Supply.—Every school should be provided with an adequate supply of pure drinking water. In cities where there is a municipal water-supply, the school should be connected with this, and taps provided in the compound in such number as is considered necessary. In other towns water should be obtained from a *pacca* deep and closed well, provided with a pump. If a pump is not provided, the well should have round its mouth, and sloping away from it, a platform with a marginal gutter opening into a *pacca* effluent drain, connected with the surface drainage of the locality, to carry off all surplus water. The well should be disinfected periodically.

Owing to the climatic conditions of the country it is necessary to store water in earthenware *chatties* to keep it cool, especially in summer. These *chatties* should be well covered with closely fitting lids, and should, under no circumstances, be placed under a staircase, or in an ill-ventilated dark room near a drain. They should be kept in double sets, so that one set might be used and the other kept exposed to the sun on alternate days. They should have a broad mouth to allow of a thorough scrubbing and washing every day. They should also be disinfected with potassium permanganate once a week. The drinking cups should be made of metal, and should be well rinsed each time before and after use in order to avoid the spread of infective diseases, such as diphtheria. The scholars should be taught to dip the lips into the water rather than grip the edges of the cup between the lips. The cups should never be dipped into the *chatty*,

but a special man, preferably a Brahmin, should be employed to pour out water into the cups.

"Crystal stream" drinking fountains, which deliver a fine upward jet of water that can be received directly into the scholar's mouth without the use of a cup, have been recommended in England, but are unsuitable for the hot climate of India.

Meals.—A separate room should be reserved for taking mid-day meals. These should be either supplied by the school, or should come from the scholars' home, but the scholars should never be permitted to purchase eatables from ordinary food hawkers, who should not be allowed to enter the premises of the school except those who are licensed vendors allowed by the school authorities. These vendors should keep their articles for sale in clean and covered utensils and in almirahs with wire-netting or glass cases, and should supply nothing but wholesome food and, if possible, quite hot.

Play-Grounds.—Play-grounds must be provided for all schools for organized games, such as football, cricket, hockey, tennis, as also for physical drill and gymnastics, but these are not very essential for village schools, as a piece of waste land is generally available in the village, which may be used for playing national games, such as *gilli danda*, *kabaddi*, etc. However, it is necessary that the school should have a small compound enclosed by a boundary wall to afford a certain amount of seclusion to the school, and to prevent the straying of cattle into the premises.

All play-grounds should be square or oblong, not cut up by buildings, should be free from dust and well-drained. Their surface should be levelled, and covered with lawns or made of material such as asphalt or granolithic cement. The size of the play-ground should vary with the number of the scholars. The space should be at least 30 square feet per scholar. The whole play-ground should be open to the sun, but it is desirable that a portion should be covered in for use

during rains. It is also desirable that a portion might be converted into a garden, if more space is available; inasmuch as gardens have an educative value and, if well kept, improve the appearance of the school. Since all the scholars cannot take part in hockey, football, etc., it is very necessary that half an hour on each school day should be devoted to physical training in drill exercises in each class, so that their physical powers and mental faculties may be developed. This should be carried out in the open air or in a large room available with doors and windows open.

HOSTELS.

The present tendency of building hostels for separate castes or communities is to be condemned. The scholars of all castes and creeds must live together, so that they may have a sort of fellow-feeling among themselves and have a wider outlook in life. The hostel building should have the front facing the north or south, but not the east or west. Each room of the hostel should be so constructed as to allow at least 50 square feet of floor area per scholar, and should accommodate two scholars. The height of the room should not be less than 15 feet. Each scholar should be supplied with a table, a chair and an iron bed with a galvanized iron or copper wire mattress. Wooden beds strung with *newar* or *moonj* should be condemned, as they harbour bugs and other vermin in large numbers. There should be a closed almirah fixed in the wall, one for each scholar, to keep his books and clothes. For the purpose of ventilation direct openings of an area of at least two square feet should be provided both in the front and back walls over the doors and windows. These should communicate directly with the outer air, be rain-protected and provided with small mesh wire-netting. A common reading room must be provided with a sufficient number of tables and chairs.

The illumination of the rooms should not be left in the hands of the scholars, as they are in the habit of using the inferior qualities of lamps, which are injurious to their eyes.

Each room should either be illuminated at night by a hanging lamp suspended in its middle at a height of 6 feet from the floor, which should be equal in candle power units to one-sixth of the floor area in feet, or each scholar should be supplied with a lamp having candle power of 8 or 10 units, and provided with a green shade to cut off direct light from falling on his eyes. The lights must be extinguished by 10 o'clock at night. Where electric light is available, inverted lamps should be hung up at a height of 6 feet from the floor in each room, and at intervals of 6 feet in a common reading room.

It is desirable to have only one dining-hall for all the students living in the hostel, but if an objection is raised by the students on the score of religion, it is advisable to provide separate dining-halls for Mahomedans, Christians and Hindus. Hindus, as a rule do not use a dining-hall, but they must be encouraged to do so at least on festivals. These halls should be furnished with a large dining table, a sufficient number of chairs, and one or two hanging lamps according to the requirements.

Kitchens should have a *pacca* floor, should be provided with chimneys to obviate the soot and smoke nuisance, and should have proper drainage to carry away the sullage. These drains should be well flushed and properly cleansed twice daily. Proper iron receptacles having well-fitting lids to prevent the accumulation of flies, should be provided for collecting dry refuse. These should be emptied and cleaned twice daily after use. The doors and windows of the kitchen should be provided with fine mesh wire-netting to keep away flies. The doors should also be self-closing ones.

A bathing platform should be provided for bathing and washing purposes. This should have a marginal drain to carry away effluent water, and should be divided into compartments by erecting partition walls. Each compartment should be provided with a tap, if there is a pipe water-supply. When water has to be taken from a well, the platform should be

constructed at some distance from it, and a reservoir of suitable size should be made to supply water to the taps. In addition to these, it is desirable to introduce one or more plunge or shower baths. If possible, each hostel should be provided with a swimming bath with clean water, where the scholars can learn the art of swimming, and enjoy their bath, especially in summer.

SANITARY CONVENIENCES.

In towns where a sewerage system exists and a suitable water-supply is available, closets of the most approved type should be provided and connected with the properly made sewers. These closets should be of the wash-down pattern connected with the flushing cistern. Trough closets should not be used. In all mixed schools separate closet accommodation should be provided for both the sexes. The number of closets depends upon the size of the school or the hostel, but the minimum should be one for every fifteen girls and one for every twenty boys. In addition to the closets, urinal accommodation is required for boys, and white glazed stalls, not slate slabs, should be introduced.

In towns and villages, where there is no system of a pipe water-supply and sewers, latrines of a separate system pattern should be provided with non-absorbent seats and walls. These should have an enclosure wall of fenestrated brick work. The provision of one latrine seat for every fifty scholars for day schools and two latrine seats for every twenty boarders for hostels is considered sufficient. In addition to these, a separate night latrine should be provided for each hostel.

Urinals having a surface of non-absorbent and smooth material, such as Indian patent stone, should be provided, so that the *moris* (drains) may not be used as urinals, or the scholars will commit nuisance anywhere in the compound of the school. Two urinals for every fifty scholars for a day school and one for every twenty scholars living in a hostel must be provided. In addition to these, removable urinals of

the Donaldson iron bucket pattern filled with saw-dust or dry earth at the rate of at least one for every twenty-five boarders should be placed at convenient places in the courtyard of the hostel for night use. These should be removed altogether in the day-time, and cleaned and replaced at night. The latrines and urinals should never be included in the main school buildings, but should be built separately and at a distance of not less than 20 feet from the main building to which they may be connected by a covered way allowing of cross-ventilation. It is also necessary that the latrines and urinals as well as the school and hostel compound should be kept in a clean and trim condition not only for the sake of the health of the scholars, but also as an object lesson in cleanliness. For this purpose it is necessary to employ one or two sweepers whose work should be supervised by the head master of the school.

PERSONAL HYGIENE OF SCHOLARS.

The age at which children attend school is very impressive, and it is, therefore, incumbent on their teachers to inculcate on the minds of their scholars the principles of personal cleanliness and the formation of regular and good habits by precept and example. They must, therefore, be tidy and clean in their person and clothing, punctual and orderly in their work, and of good moral character. They must also be trained in elementary physiology and domestic hygiene, so that they can teach elementary hygiene in schools.

Smoking, which is a very injurious habit, is now-a-days very prevalent among school-boys. Hence it should be strictly forbidden, and any scholar found in possession of a cigarette must be severely dealt with. The teachers themselves should make it a point not to smoke in the presence of their scholars. They should also explain to them the injurious effects of intoxicating drugs, such as alcohol, cocaine, cannabis indica and opium. Scholars coming to school in a dirty condition should be excluded therefrom, and not readmitted until

they are clean. They should not be allowed to spit promiscuously anywhere on the premises of the school or hostel. and a notice prohibiting spitting should be put up in every class room, and in every room in the hostel.

The system of early marriage should be discouraged, as far as possible, by gradually excluding married boys from all schools below the 9th and 10th classes. At any rate married and unmarried boys should not be allowed to mix together.

The practice of self-abuse is unfortunately prevalent in schools. This is detrimental to the physical, mental and moral well-being of the scholars. It is, therefore, very essential that teachers should take every necessary step to eradicate this evil. Every scholar must take part in physical exercises or some game, so that he may have sound sleep. No scholar should be allowed to read pamphlets dealing with pornographic literature. Any one found in possession of such literature should at once be expelled from the school.

MEDICAL INSPECTION OF SCHOLARS.

In 1907 the British Parliament passed an Act which provided for the medical inspection of school-children, and came into force in January 1908. In India no such law has been passed, but the Local Governments have made some provision for the inspection of school children by giving some special allowance to the members of the Provincial Subordinate Medical and Provincial Medical Services. Recently whole-time medical officers have been employed as medical inspectors in a few cities, but this cannot be satisfactory. The Government of India should pass an Act which should compel the educational authorities to employ whole-time medical officers with registrable qualifications, whose duty should be to inspect and report periodically about the sanitary conditions of the school and the hostel as regards the site, drainage, lighting, ventilation, superficial and cubic space, furniture, equipment, play-ground, water-supply, kitchens, pantries and

latrine and urinal accommodation, and to medically examine the school-children. In schools children are brought into intimate association with each other, so that there are ample opportunities for the spread of infectious and contagious diseases, but the institution of medical inspection would be very valuable in preventing the spread of these diseases, and would frequently lead to the timely treatment of minor ailments and defects by bringing them to their parents' notice. The medical officer should have the power to exclude scholars from school : (1) on the ground that their exclusion is desirable to prevent the spread of disease ; (2) on the ground that their uncleanly or verminous condition is detrimental to other scholars ; (3) on the ground that, owing to their state of health or their physical or mental defects, they are incapable of receiving proper benefit from the instruction in the school. He should also be authorized to order the immediate closure of the school on the outbreak of an infectious disease, such as plague, influenza, diphtheria, measles, small-pox, or pneumonia. This extreme measure should, however, be adopted under very exceptional circumstances. In country districts where the children meet only at school, such a measure may be justified ; but in towns the children will frequently meet for play when the school is closed. The usual measure to be adopted would be to exclude from school the children from affected house-holds. They should be allowed to return only when their house and clothing have been thoroughly disinfected, and they themselves are declared by a certificate from a medical practitioner that they are no longer infectious.

The following table gives the summary of rules regarding the exclusion of children from school on account of infectious diseases.

Disease.	Period of exclusion of children suffering from disease.	Period of exclusion of children living in infected houses.
Small-pox. **Cholera.**	1. Until the medical attendant certifies, if the case is treated at home. 2. Until after discharge from hospital.	Until seven days shall have passed after the date of the certificate from the Health Officer that the house is free from infection.
Diphtheria. **Membranous Croup.**	1. If the case is treated at home, until a medical certificate, based on three successive bacteriological examinations, is furnished. 2. Until a fortnight after the date of discharge from the hospital.	
Scarlet Fever or Scarlatina.	1. Until the medical certificate is forthcoming, if treated at home. 2. Until a fortnight after date of discharge.	
Erysipelas. **Enteric Fever.**	1. Until the medical attendant certifies, if the case is treated at home. 2. Until after discharge from hospital.	Not to be excluded
Measles.	At least one month.	All infants for 15 days from occurrence of the last case. Seniors not to be excluded if they have had the disease, or 15 days from occurrence of first case.
Mumps.	One month.	Infants for 3 weeks, or for such time as is considered necessary by the medical attendant. Seniors for the same period as infants, if they have not had the disease; otherwise not to be excluded.

Disease.	Period of exclusion of children suffering from disease.	Period of exclusion of children living in infected houses.
Whooping Cough.	As long as cough continues, but not to be re-admitted until at least 5 weeks from commencement of whoop.	Infants for two weeks. Seniors for two weeks if they have not had the disease ; otherwise not to be excluded.
Chicken-pox.	Two weeks or until every scale is off scalp or body.	Infants for two weeks. Seniors for two weeks, if they have not had the disease ; otherwise not to be excluded.
Ringworm. **Favus.** **Scabies.** **Ophthalmia.** **Trachoma.**	Until medical certificate is obtained that the child is cured.	Not to be excluded.
Consumption.	Exclude if the disease is accompanied by coughing or spitting.	Not to be excluded.
Leprosy.	Exclude from school.	Children, if not affected, should not be allowed to live in the same house with a leprous patient.

When primary education becomes compulsory, each child should be medically examined three times during his school course, *viz.*, once at the time of entry, once just before leaving and once at some intermediate period. At each inspection the height and weight should be taken and notes made with regard to sight, hearing, cleanliness, clothing, nutrition and the presence or absence of lesions in the heart and other organs. To keep a permanent record of these inspections it is better to have a medical history card for each scholar, to be kept in the custody of the head master. On transfer of the scholar from one school to another, this history card should be sent to the head master of that school along with his transfer certificate,

The medical history card adopted by the Educational Department of the United Provinces contains the following headings :—

Name—

Caste

Father's name—

Address

School

Date of admission

Age on admission

Vaccinated or not

Date of inspection (shown by initial of medical officer)—

	192 .	192 .	192 .	192 .	192 .	192 .
January ...						
February ...						
March ...						
April ...						
May ...						
June ...						
July ...						
August ...						
September ...						
October ...						
November ...						
December ...						

Remarks by the Inspecting Officers, Educational or Medical.

MEDICAL HISTORY SHEET.

I.—Weight and Height.

	192 .	192 .	192 .	192 .	192 .	192 .
	Weight.	Weight.	Weight.	Weight.	Weight.	Weight.
January ...						
April ...						
July ...						
October ...						
Height ...						

Note.—Weights should be copied from the weight registers.

II.—Physical condition.

Code :—

N = Normal.
A = Absent.
— = Disappeared.
+ = Present to slight degree.
+ + = Present to medium degree.

Examined for	Condition.	192 .	192 .	192 .	192 .	192 .	192 .
1. General appearance ...							
Cleanliness							
2. *Teeth*: (1) No. carious ...							
(2) Pyorrhœa ...							
3. *Throat and nose*: (1) Adenoids ...							
(2) Tonsils ...							

Examined for	Condition.	192 .	192	192 .	192 .	192	192 .
4. Any glandular enlargement ...							
5. *Ears* : (1) Middle ear disease ...							
(2) Hearing ...							
6. *Eyes* : (1) Disease of lids.							
(2) Vision ...							
7. Speech ...							
8. General mental condition ...							
9. *Any special disease* :							
(1) Respiratory ...							
(2) Circulatory ...							
(3) Alimentary ...							
(4) Nervous ...							
10. *Anaemia* :							
(1) Size of spleen ...							
(2) Evidence of parasites or other disease ...							
11. Any general disease, e.g., goitre, ring-worm, etc...							

Special Schools.—Separate special schools should be provided for mentally defective children; but it should be remembered that many of the children who are regarded dull and backward by their teachers are proved to be so only because they are suffering from defective vision or defective hearing probably due to the adenoids and enlarged tonsils. Others are so called because they are word blind as a result of some defect in the conditions between the receptive and perspective centres in the brain.

Special schools should also be opened for the blind, deaf and dumb.

CHAPTER X.

CLIMATOLOGY AND METEOROLOGY.

CLIMATOLOGY.

Climatology.—Climatology deals with the combined effects of the atmospheric and earthly conditions with reference to their suitability to animal and vegetable life.

The principal factors determining the climate of a locality are:—(1) The latitude with reference to the terrestrial equator; (2) The distance from the sea-side; (3) The altitude; and (4) The prevailing winds. Besides these, there are a few other local conditions that are likely to modify it, *viz.*, proximity to cultivated lands, sub-soil drainage, presence of vegetation, neighbourhood of forests, congestion of dwelling houses and manufactories, if any, situated in the locality.

Classification of Climate.—Climate is classified on the principle of the latitude as follows:—

(1) **Warm Climate.**—This comprehends the sub-varieties, equatorial, tropical and sub-tropical, and prevails within an area of 35° on either side of the equator, within which, geographically speaking, are comprised Southern Asia including India and China, Polynesia including all Australia excepting Victoria, Africa, North America south of California and South America north of Uruguay with the West Indies. Its characteristic features are prevalence of more or less high temperature, heavy rainfall and well-defined dry and wet seasons. In the equatorial region the temperature varies within a wide range of 54° F., and 118° F., the mean varying from 80° F. to 84° F.; but the warmth is considerably lessened on account of heavy rainfall amounting, on an average, to about 40 inches in the year. There is a slight difference of temperature during the day, but a marked fall is usually noticed at night owing to radiation. The commoner affection

that are attributable to warm climates are heat stroke, yellow fever, cholera, dengue, liver abscess, dysentery, diarrhœa, small-pox, malarial fever and kala-azar.

(2) **Desert Climate**.—This is, to some extent, allied to warm climate, and is characterized by heat, dryness and greater purity of air. Pathogenic micro-organisms, specially those derived through a process of fermentation, are unable to thrive in such a climate as is evidenced by the comparative scarcity of cases of pulmonary consumption and the rapidity of healing of surgical wounds. An extreme variation of day and night temperatures is, however, commonly met with owing to a rapid radiation of heat from the sandy soils.

(3) **Temperate Climate.**—This prevails within the latitudes of 35° and 50°, which includes Central and Southern Europe with its islands, the part of Asia between the Mediterranean, the Black Sea and Japan, a large part of North and South America, South Uruguay, Victoria in Australia, New Zealand, Tasmania and numerous isles in their vicinity. It has four well-defined seasons with a greater rainfall in autumn and winter, and has a mean temperature varying between 50° and 60° F. The races inhabiting these localities with its influence are, therefore, naturally found to possess a more vigorous physique, but kidney and lung troubles as well as rheumatism, diphtheria and influenza are more prevalent in these regions.

(4) **Cold Climate.**—This prevails in regions lying within 50° of latitude from the poles. Here winter is severe and long, lasting for ten months and summer is short, often lasting a few weeks. Rainfall is scarce, while the fall of snow is abundant. The mean annual temperature varies between 40° F. and 50° F., and is 25° F. in the arctic circle in 60° of latitude. Owing to a lack of vegetables and fruits, people suffer from scurvy, and they suffer from scrofula or tuberculosis owing to overcrowding and poverty prevailing there. The people are also said to suffer from ophthalmia and amaurosis from reflection of light

from the snow in the polar regions. However, dry and severe cold makes the inhabitants hardy and muscular, and improves their appetite.

(5) **Mountain Climate.**—This is to be found chiefly in places about 3,000 feet above sea-level, and is characterized by diminished atmospheric pressure, and rarefaction and purity of air. There is generally a lowered temperature, but owing to the rapid heating of the soil by the sun the days may be warm during summer, whilst the nights become very cool owing to a sudden fall of the temperature from the rapid radiation of heat immediately after the setting of the sun. As a rule, temperature decreases about 1° F. for every 300 feet of altitude. Besides, less moisture, a greater amount of ozone and the prevalence of strong winds are met with in the mountain climate. In the hill stations of the Himalayan ranges the climate, though cool, is subject to considerable extremes, and is damp owing to excessive rainfall.

The mountain climate is very beneficial to persons suffering from phthisis in an early stage without much congestion and bronchitis. Spots selected for them should be those which are sheltered from cold winds. It is no good for these persons to go and live in crowded houses or in the *bazaars* without taking any precautions. It is also good for persons suffering from anæmia, spasmodic asthma without emphysema, and chronic pleurisy, but is bad for persons suffering from chronic bronchitis and emphysema, bronchiectasis, diseases of the heart and great vessels, affections of the kidneys and liver, and those of the brain and spinal cord. No patient should be allowed to go to the hills, who cannot take abundant exercise. The aged and very feeble persons should, therefore, be debarred from going there.

(6) **Marine or Ocean Climate.**—This denotes what prevails in islands, capes and at sea-side places, and is characterized by an equable temperature, greater humidity and a copious rainfall. The atmosphere in these regions is rich in

ozone, and free from dust and germs. Rheumatism is, however, common in such a climate but, on the other hand, lung diseases, such as bronchitis, emphysema and congestive phthisis are often cured by a change to such a climate.

Climate in relation to Health.—The human body has got wonderful powers of adaptability which enable it to accommodate itself with varying climatic conditions; yet the various races have also well-defined limits of endurance; and, if placed under conditions which would tax them beyond such limits, their health is liable to deteriorate considerably. For instance, the health of Europeans has been known to suffer largely when they come to reside for long in tropical countries. On the contrary the dark races of the African tropics, in migrating to temperate climates, become markedly predisposed to pulmonary complaints, especially phthisis.

Apart from the injurious influences of extreme climatic conditions there are certain affections met with amongst Europeans in India that are directly attributable to improper and unsuitable diet.

EFFECTS OF TEMPERATURE.

(*a*) **Cold.**—Prolonged exposure to cold causes contraction of the surperficial blood vessels, and specially the terminal arterioles of the extremities resulting in frostbite and gangrene of the fingers and toes. It further causes lassitude, torpor followed by deep sleep, insensibility and coma. Sometimes such attacks of torpidity are varied by those of delirium.

(*b*) **Heat.**—The effects of the direct rays of the sun on the body are, when not very powerful, highly beneficial, as is evident by comparing the pale faces of the people living in insanitary buildings of the cities into which they do not have access, with the ruddy cheeks and vigorous appearances of those living in the open localities in villages and towns; and it is truly said that "Where the sun does not enter, the physician will." But prolonged exposure to heat whether in the sun or in the shade produces marked physiological disturbances.

Heat diminishes the number of respirations from 16.5 (England) to 13.74 and even to 12.74 in the tropics. Water exhaled from the lungs is diminished, and so is the amount of urine and urea. On the other hand there is a great increase of perspiration. This may lead to an irritation of the sweat-glands known as prickly-heat. As all successful remedies for prickly-heat contain antiseptics, there can be no doubt that the disorder is due to a microbe whose growth is favoured by the abnormal activity of the sweat-glands. The process of metabolism suffers largely, resulting in a loss of appetite, and the liver becomes congested and indurated. Apart from malarial and other parasitic diseases peculiar to tropical countries, continued residence in them may also bring about a sort of languor, both mental and physical, premature senility and a general lowering of the expectation of life.

The human body can adapt itself to large variations of temperature with the perspiration invoked by its excess, but directly this process happens to be in abeyance, this heat-regulating state of equilibrium comes to be disturbed, and as a consequence injurious effects of heat-stroke manifest themselves. The most enervating effects of heat are experienced, when it is continuous and associated with considerable humidity. Heat can be better tolerated, when the air is in motion than when it is still.

(*c*) **Humidity.**—A large amount of humidity in the surrounding air offers an injurious check to a process of free cutaneous perspiration and respiratory evaporation; besides, it is liable to foster attacks of coryza and respiratory catarrh. It also prevents the free radiation of heat from the earth, and favours putrefaction. Malarial fevers, plague and small-pox are said to flourish in a humid atmosphere.

(*d*) **Rainfall.**—This exerts a beneficial influence by reducing the atmospheric moisture and by washing down impurities and microbes contained in the air, but in excess it

becomes a source of serious danger on account of its carrying down a very large number of disease-bearing germs into tanks and wells, the stagnant water of which eventually aids their considerable proliferation. A considerable amount of rain also exerts a sort of relaxing effect on the climate of a locality.

(*e*) **Atmospheric Pressure.**—The effects of a diminished atmospheric pressure are of great importance in connection with residence in high altitudes, and balloon and aeroplane ascensions. These effects are mainly due to deficiency in oxygen in the rarefied atmosphere, and are generally felt at an altitude of 6,000 or 7,000 feet and over, especially after muscular exertion. They consist in an increase in the pulse rate, and in the depth and frequency of respirations, as also in mountain sickness with headache, nausea, vertigo, muscular weakness, and possibly bleeding from the nose and ears.

It is a well-known fact that persons are able gradually to acclimatise themselves to a rarefied air at high altitudes, which would overcome persons if the change was made suddenly from sea-level. The method of acclimatisation is by the development of an increased number of red blood corpuscles in order to provide the body with additional oxygen carriers to deal with the rarefied air. The number of corpuscles increases with the proportion of the altitude, and when a sufficient number has been developed in accordance with the altitude, then the acclimatisation is complete. If the ascent is gradual, the manufacture of the red blood corpuscles keeps pace with the requirements of the altitude and no inconvenience is felt. If, on the other hand, the ascent is rapid, then a sufficient number of corpuscles has no time to develop, the blood is relatively deficient, and mountain sickness is the result. If the stay is prolonged after the altitude is reached, acclimatisation occurs gradually, and distress disappears.[1]

1. R. W. G. Hingston, Physiological Changes at high altitudes and their relation to mountain sickness, Indian Journal of Medical Research, Vol. IX, 1921-22, p. 173.

The effects of an increased air pressure are observed in submarine work, diving, caisson work, etc., and are chiefly due to an increase in the amount of atmospheric gases (especially nitrogen) which are taken up by the blood, and also an increase in the chemical absorption of oxygen by the blood. It is, however, noticed that the system soon gets accustomed to increased air pressure, and men are found to work without any ill-effects in deep mines and diving bells. It should be remembered that a pressure of 5 to 6 atmospheres continued for a long time may cause injurious or fatal results, and a pressure of 15 atmospheres generally causes death with convulsions.

An affection, known as "Caisson Disease" is, sometimes, found in divers and workers in caissons (compressed air chambers made of wood or steel sunk under water) owing to high atmospheric pressure in which they have to work. The symptoms consist of pains in the ear owing to pressure upon the drum or its rupture in some cases. There are also excruciating pains in the joints and muscles, epigastric pains, and vomiting. Occasionally there are headache, giddiness, epistaxis, dyspnœa and paralysis. Sometimes death may occur from internal hæmorrhage. These symptoms occur during or after decompression to return to the outside air. The serious consequences usually result from a too rapid decompression. When this occurs, the gases in the blood, particularly the nitrogen, are suddenly liberated, forming emboli, which may block the capillaries leading to hæmorrhage and resulting in paralysis, or may lodge in the vital organs and cause sudden death. If the decompression is effected gradually, no evil effects result, as the gas gets a chance to escape slowly without the formation of gas bubbles.

METEOROLOGY.

Meteorology is the science with treats of atmospheric phenomena in relation to weather and climate. The principal factors requiring systematic observations and records are the

atmospheric pressure, temperature, humidity, the force and the direction of winds, sunshine, the presence or the absence of clouds, mists, fog, storms and rainfall.

Atmospheric Pressure.—The atmosphere at the sea-level exerts a pressure of about 14.64 lbs. per square inch, and sustains a column of mercury about 30 (29.92) inches or 760 millimetres in height. Similarly it can sustain a column of water about 34 feet in height, and that of glycerine about 324 inches in height. But mercury being more convenient is generally used for measuring the atmospheric pressure, and the instrument used for the purpose is known as "barometer".

The simplest form of a barometer consists of a glass tube about 33 inches long, closed at one end and open at the other, filled with pure mercury and inverted with the open end vertically downwards in a basin of the same fluid, care being taken that no air is allowed to enter the tube. The space above the column of mercury in the tube is a perfect vacuum, and is called the Torricellian vacuum.

The siphon barometer consists of a bent glass tube of uniform calibre, one leg being much larger than the other. The long leg is sealed at the top, and is filled with mercury, while the short leg is open and serves as a cistern. The difference between the levels in the two legs is the height of the column of mercury supported by the atmosphere.

The cistern barometer consists of a tube as described above, filled with mercury and inverted in a vessel containing the same fluid, called the cistern. The whole is fixed to a scale. It is convenient to read the height by a scale fixed to the tube, but as the pressure varies, mercury flows into or out of the cistern and the scale zero must constantly be shifted to coincide with the mercury surface. To obviate this difficulty Fortin's barometer is constructed. In this barometer the bottom of the cistern is made of wash-leather capable of being raised or lowered by means of a fine screw, while immediately above the mercury is a small ivory pointer (fiducial point), whose tip

coincides with the zero of the scale. Before taking a reading of the barometer the screw should be turned until the mercury just touches the bottom of the pointer, and the scale zero is on the liquid surface. The scale is divided into inches, tenths and half-tenths (1/20) of inches. To obtain more accurate readings a vernier or sliding scale is attached, which is moved over the graduated scale by a rack and pinion. The vernier scale is divided into twenty-five parts which are equal to twenty-four divisions of the barometric scale. Consequently each vernier division is 1/25 less than a half-tenth division of the barometric scale, and is therefore 1/25 of 1/20 inch, *i. e.*, 1/500 or 0.002 inch.

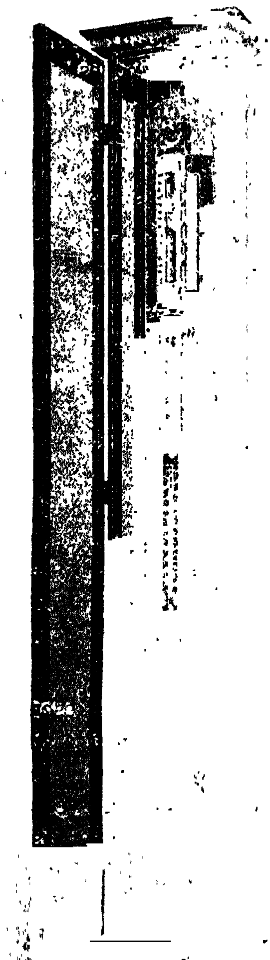

Fig. 12—Fortin's Barometer.

The height of the mercury column varies with the temperature on account of the expansion of the mercury and of the brass scale. It is, therefore, necessary to reduce all barometric readings to a standard temperature of 32°F. or 0° C. The necessary temperature is noted by means of a thermometer attached to the column.

The location of a barometer is very important. It should be suspended in a correctly vertical position in good light, but away from direct sunlight and sources of a tropical heat.

The aneroid barometer contains no mercury. It consists of a small watch-shaped metal box which is exhausted of air, and the two sides of the box are kept apart by a series of strong but sensitive springs. When the air pressure increases, the sides of the box are pressed inwards, and when the pressure diminishes the sides bulge out. These movements are made to turn an index on the dial of the box by means of an arrangement of suitable levers. The instrument being easy of transport serves a useful purpose on ships and aircraft. It is also valuable for estimating altitudes.

Temperature.—The atmospheric temperature is measured by an instrument, called a thermometer, which consists of a glass tube, having a narrow capillary bore with a bulb blown at one end of it, the other end being closed. Both the bulb and a part of the capillary tube are filled with mercury or alcohol, and the expansion or contraction is measured by a graduated scale either on the tube itself, or on a frame to which it is attached. There are three thermometric scales in use, *viz.*, the Fahrenheit scale, the Centigrade scale, and the Réaumur scale In the Fahrenheit scale the freezing point is called 32 degrees and the boiling point 212 degrees. The interval between the two limits is divided into 180 degrees. This is commonly used in England and in this country especially for non-scientific purposes. In the Centigrade scale the freezing point is called zero, and the boiling point 100 degrees. The space between the two points is divided equally into 100 degrees. This scale is now chiefly used by men of science. In the Réaumur's scale the fixed points are zero and 80 degrees, the interval being divided into 80 degrees. This scale is extensively used in Germany. To convert from one scale to another the following formulæ are used :—

$$F = 9\,C/5 + 32. \qquad C = (F - 32) \times 5/9.$$

$$F = 9\,R/4 + 32. \qquad R = \frac{4\,(F-32).}{9}$$

$$R = 4\,C/5. \qquad C = \frac{5\,R.}{4}$$

Several kinds of thermometers are used in the observatories in India for recording the temperature. The following are a few in common use :—

(1) The standard or dry bulb thermometer for taking the temperature at the moment of observation. This usually contains mercury, and is used for testing the accuracy of ordinary thermometers.

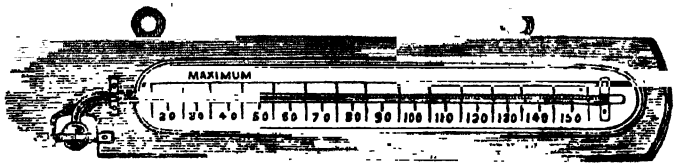

Fig. 13—The Maximum Thermometer.

(2) The maximum thermometer for registering the highest temperature attained in the day or any other period. The two chief forms of the maximum thermometers are those of Philip and of Negretti. In Philip's thermometer part of the mercury column is separated from the main body of the liquid by a minute bubble of air. The instrument when in use is placed in a horizontal position. When the mercury expands owing to a rise of temperature, the pressure of the air pushes this broken column on before it, but the column does not recede when the mercury again contracts owing to a fall of temperature. Thus the highest temperature reached is registered.

In Negretti's thermometer the detachment is made by a slight contraction of the lumen of the tube, which allows the expanding mercury to pass but prevents it from returning when the temperature falls, and the mercury contracts.

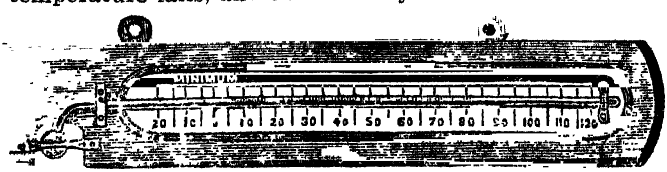

Fig. 14—The Minimum Thermometer.

(3) The minimum thermometer for registering the lowest temperature during the night or early morning. In Rutherford's minimum thermometer a small glass index is enclosed in the spirit which fills the bulb and part of the stem. In setting the instrument the index is first brought to the top of the column of the spirit, and the instrument is then placed in a horizontal position. When the temperature rises, the spirit expands and flows past the index; but when the temperature falls, the spirit contracts and carries the index with it rather than admit of the concave capillary surface of the liquid being broken. The lowest temperature reached is thus registered. The instrument can be readily readjusted by tilting it and letting the index fall to the end of the spirit in the stem.

Six's thermometer consists of a U-shaped tube having a bulb at each end and containing both mercury and alcohol. It registers both maximum and minimum temperatures. Steel indices are placed in both legs of the tube, and record the expansion and contraction of the alcohol. These are brought back into position by means of a magnet. It should be remembered that this instrument is hung in a vertical position.

Besides these, the following varieties of thermometers are also used for determining the humidity (*i.e.*, the dryness or dampness) of the air :—

(4) The wet and dry bulb thermometer, by which the humidity of the air at the time of observation is ascertained. This consists of two thermometers mounted side by side. One, the dry bulb, gives the temperature of the air. The other, the wet bulb, is covered with loose muslin or cotton wool, which dips into a small receptacle of water placed immediately below. Owing to evaporation from the muslin the temperature of the wet bulb is lower than that of the dry bulb. This difference in the temperature is connected with the humidity of the atmosphere, for if the air is dry, the evaporation will be rapid, and the difference in the temperature will

be great. If, however, the atmosphere is saturated with moisture no evaporation will take place, and the two thermometers will show exactly the same readings.

The dew point, *i.e.*, the temperature at which the air is saturated with moisture can be found when the temperatures of the two thermometers are known. The following formula may be used for the purpose :—Dew point = Td—F (Td—Tw), where Td and Tw represent the temperatures of the dry and wet bulbs, and F the factor opposite the dry-bulb temperature found in Glaisher's tables.

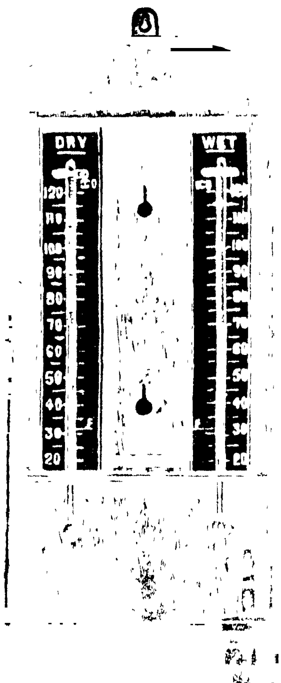

Fig. 15—The Wet and Dry Bulb Thermometer.

(5) The wet minimum thermometer by which humidity at the coolest time of the night is ascertained.

These thermometers must be freely exposed to currents of atmospheric air. In Indian observatories they are placed within a wire enclosure under a thatched shed, thus well secured against the inclemencies of the weather.

(6) The terrestrial radiation thermometer, by which the amount of loss of heat given off by radiation from the ground is measured. It is a minimum thermometer, and is placed horizontally 4 inches high from the ground, preferably in an open plot of grass. The difference between the minimum temperature of the air taken in the shed and the minimum temperature of this instrument is the amount of terrestrial radiation.

(7) The solar radiation thermometer for measuring the intensity of the heat given off or radiated by the sun. It consists of a maximum self-registering thermometer having a bulb and one inch of the stem coated with lampblack, and placed in a glass case from which the air is exhausted. The bulb and the stem are blackened to prevent the loss of heat by radiation from a bright surface. This instrument is exposed to the sun's rays, and placed horizontally 4 feet above the ground away from trees and walls of houses. The difference between the maximum temperature recorded by this instrument and the maximum temperature of the surrounding air shown by a thermometer in the shade indicates the greatest amount of solar radiation during the day.

(8) The Kata-thermometer to measure the cooling power of the air at a given time and place. This instrument as originally devised by Leonard Hill consists of two large-bulbed spirit thermometers graduated from 90° to 110° F. One of the bulbs is used uncovered as a dry bulb thermometer (the dry Kata-thermometer), and the other is covered with a muslin cloth and is used as a wet bulb thermometer (wet Kata-thermometer). The bulbs are first heated in water to about 100° F., and the uncovered bulb is wiped dry with a clean cloth and the muslin covered bulb is shaken to remove the excess of moisture.

Both instruments are then suspended in air, and the time of cooling from 100° to 90° F. is noted with a stop-watch and the mean of three observations is taken. The dry bulb gives the rate of cooling by radiation and convection, and the wet bulb records the rate of cooling by radiation, convection and evaporation. The bulbs which are now prepared are graduated only from 95o to 100o F., and are calibrated in order

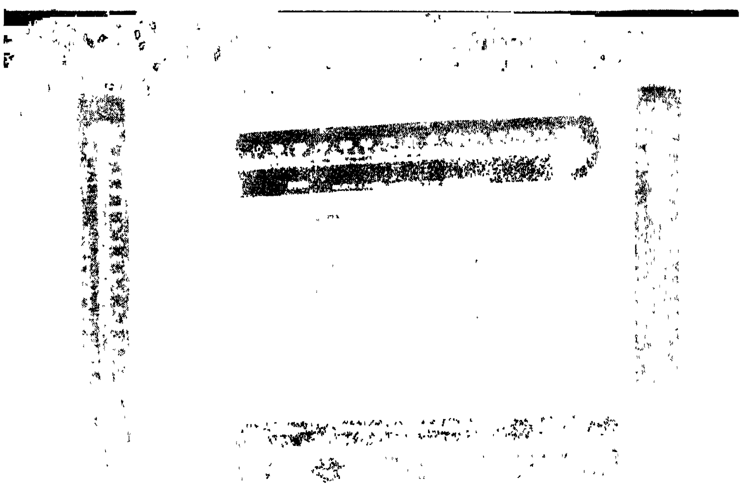

Fig. 16—Arrangement of Thermometers in an Indian Observatory.

to find the water equivalent or Kata-factor. It is easy to calculate the rate of cooling of the air in millicalories per square centimeter per second. The factor divided by the number of seconds taken by the air to fall from 100o to 95o F. gives the rate of cooling at body temperature in millicalories per square centimeter per second.

Winds.—The direction of the wind is indicated by a vane commonly known as "weather-cock." An ordinary form of

it consists of a balanced lever turning freely on a vertical axis, the broad end of which comes to be exposed to the prevailing current, while the narrower end points to the direction from which the wind may be blowing. It should be fixed on the highest accessible point. If on a building it should be fixed on its highest point and at least four feet above it. Large trees and buildings in the neighbourhood are always objectionable.

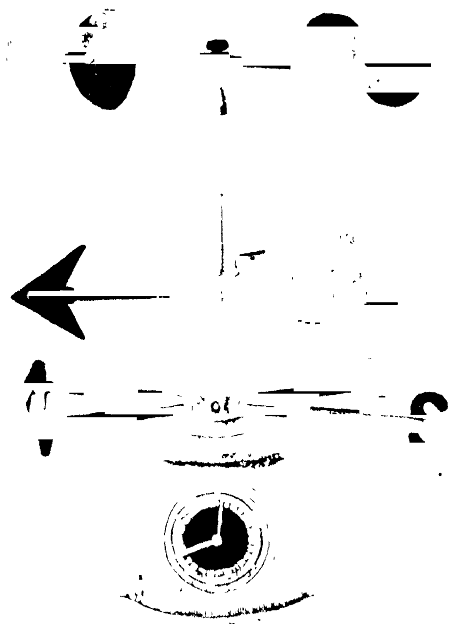

Fig. 17—Robinson's Anemometer with a Vane.

The velocity of the wind can be estimated by Robinson's anemometer, which consists of four small cups fixed at the ends of horizontal iron spikes of such a length as will enable it to measure a mile by 500 of its revolutions. By means of an additional contrivance consisting of clock-work and a dial, the number of miles traversed by the wind in a given time can be roughly determined. The anemometer should be placed at

least 20 feet above the ground, and fixed as rigidly as possible to its supports so as to be free from all oscillating movements even in the strongest winds.

Winds are produced by differences in atmospheric pressure, which in turn are caused by changes in temperature and moisture. Whenever the ground is heated, the air in contact with it expands, rises, and so lessens the pressure, thus allowing the air from colder regions to flow in as wind. Winds are classified as permanent and periodic. The trade and anti-trade winds are permanent, and periodic are those which occur only at certain seasons, *e.g.*, the monsoon of the Indian seas. The land and sea breezes depend on the same principle.

Fig. 18—The Sunshine Recorder.

Sunshine.—The hours of bright sunshine are recorded

by instruments, called sunshine recorders. There are two varieties of them. One is called Campbell Stoke's sunshine recorder. It consists of a glass sphere, which focuses the sun's rays on a strip of graduated millboard, making a burnt track, when the sun shines. The Millboard is so placed that the definite sections of it correspond to hours. The other is Jordan's photographic recorder, by which a straight line of sunlight is recorded on sensitized paper placed in two semi-circular dark chambers. A ray of sunlight is admitted through small slits made in the sides of these chambers. Owing to the earth's rotation the sunlight travels over the paper, and leaves behind a mark of its duration and intensity.

Clouds.—These consist of collections of condensed aqueous vapour, and are meteorologically classified into the four following principal types :—

1. Cirrus, or white and feathery-looking streaks, which are associated with south-westerly winds. They are the loftiest in elevation of all clouds, and are 20,000 to 30,000 feet above the earth.

2. Cumulus, or heaped-up masses, occurring at elevations of from 4,000 to 6,000 feet.

3. Stratus, or horizontal bands of cloud. These are usually seen at sunset, and foretell fine weather. They are the lowest in elevation of all clouds.

4. Nimbus, or dark masses discharging rain or snow.

Combinations of these varieties are commonly seen. They exercise a great influence on the temperature, preventing radiation from the earth's surface, and absorbing much of the heat radiating from the sun. The amount of cloud present in the visible sky is estimated by a scale 0—10, the former representing a cloudless sky, and the latter one wholly overcast.

Rainfall.—The quantity of rain that falls is measured by an instrument called a rain gauge, which consists essentially of a copper circular funnel and a receptacle made of

glass. The funnel is usually five inches in diameter. The water received is measured in a small graduated measure, the capacity of which is designed to indicate half an inch of rain.

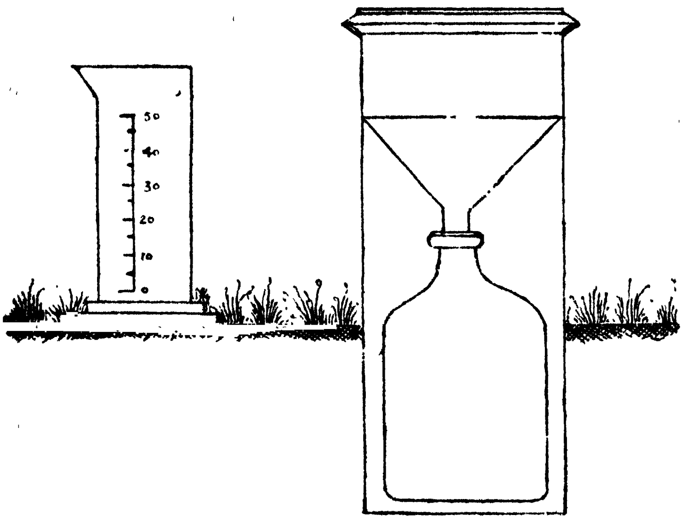

Fig. 19—The Rain Gauge.

An inch of rain represents about 101 tons of water per acre, *i.e.*, 4.67 gallons per square yard. To measure hail or snow it is necessary to melt it by means of heat or by adding a known quantity of hot water. The rain gauge should be fixed in the ground to such a depth that the edge of the rim is at least 12 inches above the surface and perfectly level. It should be in an open place, as far from trees, houses and other obstructions as possible.

Weather Forecasts.—These are issued from the central meteorological offices, and depend to a large extent upon a knowledge of the barometric pressure and cyclonic and anti-cyclonic disturbances prevailing at various points over a very extensive area. The readings of the barometer taken daily at the same time (8 A.M.) at several places in India are

telegraphed to Poona, where they are laid down upon a map or chart. On this chart lines called "isobars" are drawn connecting the places showing the same barometric pressure. These lines form circles or ellipses with, in some cases, the lowest, and in other cases, the highest pressure in the centre. A cyclone is formed, when the lowest pressure is in the centre. The anti-cyclone is formed in those cases, in which the pressure is highest in the centre.

CHAPTER XI.

FOOD.

FOOD, as ordinarily defined, consists of substances ingested through the digestive tract, where they, as a rule, undergo certain changes to befit them for assimilation. Food is a necessity of life, as it supplies nutrition to the body, repairs the body tissues and also constitutes a source of its heat and energy for the performance of work.

CLASSIFICATION OF FOOD STUFFS.

These food substances are classified into organic, inorganic and food auxiliaries. The organic are again subdivided into nitrogenous, such as proteins, and non-nitrogenous, such as (*a*) hydrocarbons or fats, (*b*) carbohydrates, *e.g.*, starch and sugar, (*c*) vitamins, and (*d*) vegetable acids. The inorganic are mineral salts and water, and food auxiliaries consist of condiments, such as various sorts of Indian "masalas" and beverages, such as tea, coffee, cocoa, alcohol, etc.

Proteins.—Chemically proteins contain 16 parts of nitrogen, 54 parts of carbon, 22 parts of oxygen, 7 parts of hydrogen and 1 part of sulphur. In the process of digestion they are first converted into soluble peptones and albumoses, and finally into amino-acids by way of hydrolysis. These amino-acids are absorbed into the blood and carried to the tissues where they are again grouped together to constitute the approximate proteins of the tissues.

Proteins are derived from both classes of food—animal and vegetable. Animal proteins are said to have the advantage of easy assimilation, but their metabolic products, when produced in excess or more rapidly than they can be destroyed or eliminated, tend to accumulate into the system giving rise to various toxic and diathetic conditions; for instance, gout and certain derangements of the liver and kidneys.

Proteins may be divided into two groups. The first group consists of proteins, such as fibrin, myosin, glutin, casein and legumin, constituting true albumins. They are easily converted into soluble peptones and albumoses by the action of gastric juice in the process of digestion, and are thus more diffusible and easier of absorption into the blood and lymph streams. The proportion of nitrogen to carbon in them is nearly 2 to 7.

The second is known as the albuminoid group, which comprises substances derived mainly from animal tissues, such as gelatin, chondrin and keratin. Their nutritive value is very small, but they are largely used in the form of vehicles, such as jellies. The proportion of nitrogen to carbon in these is 2 to 5.5.

The nutritive functions of nitrogenous foods, therefore, lie principally in the formation and repair of tissues and in supplying the digestive and other fluids of the body. A certain proportion of them, by being decomposed directly in the blood, helps in the maintenance of animal heat and the development of energy.

Hydrocarbons or Fats.—These are compounds of glycerine and fatty acids, such as oleic, stearic, and palmitic. They do not contain any nitrogen but only carbon, hydrogen and oxygen. In the process of digestion they are broken up, and emulsified by the pancreatic juice and bile, and are thus readily absorbed by the lacteal vessels; but a small portion of them is saponified. The chief function of fats is to repair and renew the fatty tissues, to supply energy and to maintain the body heat derived through a process of their oxidation and decomposition into carbon dioxide and water. They also help in removing the effete products of the system. Fats are largely consumed by people in cold climate, as they yield, weight for weight, more than twice as much energy as carbohydrates.

Animal fats are more easily digested than vegetable fats. If, however, there is an excess of fat in a particular dietary,

it is liable to pass unchanged through the digestive tract and in its course to set up decomposition. The examples of fats are *ghee* or butter, olive and mustard oils, beef fat, etc.

Carbohydrates.—These are derived chiefly from vegetable food, and are taken mostly in the form of starch. They all contain carbon, hydrogen and oxygen, the two latter in proportion almost similar to that of water. By the action of saliva and the pancreatic juice the starch is converted into grape sugar; this is absorbed into the blood, and carried mainly to the liver, where it is stored up as glycogen to be given out to the system again as a source of maintaining the body heat and furnishing energy by its eventual breaking up into carbon dioxide and water. Each gramme of sugar on oxidation yields 4 calories of heat, and since the carbohydrates form a greater portion of our daily diets and are easily oxidized in the body, they must be regarded as a chief source for the supply of the body heat. However as a result of the incomplete combustion of the carbohydrates adipose tissue may also be formed. They are also responsible for helping largely the digestion of proteins and maintaining reactions of various bodily secretions and excretions.

Vitamins.—These are organic substances of an unknown chemical nature, called "accessory food factors", and are essential to the normal growth and nutrition of animals. They exist in minute but sufficient quantities in the natural food stuffs of a vegetable origin. Their presence in animal tissues and in the products of their activity has been proved by experiments to have been originally derived from a vegetable source. The part played by them in normal metabolism is obscure, but possibly they act as catalysts or hormones.

The varieties of vitamins that have so far been recognised are—

(1) Vitamin A or Fat Soluble A.

(2) Vitamin B or Water Soluble B.

(3) Vitamin C or Water Soluble C.
(4) Vitamin D or Fat Soluble D.
(5) Vitamin E or Fat Soluble E.

There is, however, every probability that more varieties of the vitamins will be found out by further researches.

(1) **Vitamin A or Fat Soluble A.**—This is a substance which is very necessary for promoting growth, especially in the young. It is chiefly found in cod-liver oil, fresh butter, yolk of eggs, fresh milk and green vegetables. In fact it is present in all animal fats, but almost absent in vegetable fats.

Takahashi, the Japanese investigator, reports having succeeded in isolating vitamin A as a pure compound from codliver oil, which he calls biosterin. But Professor J. C. Drummond does not think that it is possible to isolate this vitamin A or to find out its exact chemical nature, though he thinks that it is not a labile, ill-defined compound, as was imagined at one time, when it is known that it is not destroyed by such drastic chemical treatment as saponification with boiling alkalies and distillation at temperatures over 200° C.[1] Oils containing it, when dissolved in petroleum ether and treated with concentrated sulphuric acid give a deep blue or purple colour reaction. Rosenheim and Drummond[2] have discovered a more delicate test for determining the presence of vitamin A. It is carried out by adding 1 c.c. of pure arsenic trichloride to 1 drop of cod-liver oil in a test-tube and shaking it at once, when the oil dissolves immediately and forms a solution of a clear ultramarine blue colour, which in the course of a few seconds assumes a purple colour, which fades gradually.

(2) **Vitamin B or Water Soluble B.**—This is the anti-neuritic factor, and is found in all the parts of plants, *viz.*,

1. Lancet, Feb. 6, 1926, p. 278.
2. J. Pryde, Recent Advances in Biochemistry, 1926, p. 223.

roots, tubers, stems, leaves, seeds and fruits. In the pulses it is distributed throughout the seeds, but in the cereals it is found chiefly in the germ or embryo and the outer layers, the very parts, which are removed in the process of milling. It is also present in yeast and to some extent in the glandular organs and eggs.

Vitamin B is much more stable than the other vitamins. It is not destroyed by drying or cooking at 100° C., unless prolonged for a long time. It is rapidly destroyed by a temperature of 120° C. It is also affected by alkalies but not by acids. It is soluble in water from which it is absorbed by Lloyd's reagent (hydrosilicate of alumina).[1]

(3) **Vitamin C or Water Soluble C.**—This is called the anti-scorbutic vitamin. It is found largely in fresh fruits, such as oranges, lemons, tomatoes, etc., and fresh green vegetables, such as cabbage. It is also contained in roots and tubers, such as onions, turnips, potatoes, and in small quantities in milk and fresh animal tissues. It is absent in dried pulses and cereals, but is present when they are germinating. This vitamin is destroyed by prolonged heating, drying and other methods employed for preserving foods, but in the case of fruits, particularly oranges and tomatoes a greater portion of the vitamin is not affected by the process of canning owing to the protective action of the acids. It is rapidly destroyed by alkalies, hence it is not desirable to use sodium carbonate or bicarbonate in cooking vegetables. Delf[2] suggests that this vitamin withstands heating above 100° C., if the heating is conducted in the absence of air.

(4) **Vitamin D or Fat Soluble D.**—This is the anti-rachitic vitamin, and is found in all those food stuffs in

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1. J. J. R. Macleod, Physiology and Biochemistry in Modern Medicine, Ed. V, p. 809.

2. Biochemical Journal, 14. 211, 1920; Howell, Text-Book of Physiology, Ed. VIII, p. 905.

which vitamin A is present. But being more stable than vitamin A it is not generally destroyed by heating in the presence of air. Thus, cod-liver oil, on being subjected to the action of oxygen for twelve to twenty-eight hours, loses vitamin A, but retains vitamin D. It also differs from vitamin A in the fact that it does not give the colour reaction with arsenic trichloride or with pure sulphuric acid, when dissolved in petroleum ether.

Steenboch[1] and his co-workers have demonstrated that many natural food stuffs and vegetable oils which are lacking in vitamin D can be endowed with anti-rachitic properties by subjecting them to ultra-violet radiations. Professor J. C. Drummond[2] has shown from his experiments that the whole of the fat-soluble vitamins are contained in the 1 per cent. of the non-saponifiable or cholesterol fraction of the fat or oil, such as cod-liver oil, a substance which is almost universally distributed in living cells. He has further shown that the exposure of chemically pure cholesterol to ultra-violet light causes the formation of vitamin D.

(5) **Vitamin E or Fat Soluble E.**—This is a third vitamin of the fat soluble class, the presence of which has been demonstrated by Professor E. H. Evans.[3] It plays an important part in promoting reproduction, and is, therefore, known as the anti-sterility vitamin.

It abounds largely in wheat germ oil, and is present in high concentration in other cereal embryos, the green leaves of plants, such as lettuce, alfalfa, pea, etc., and in low concentrations in various other vegetable oils. It is present in a very minute quantity in animal fats, such as milk fat and cod-liver oil.

This vitamin is much more resistant than the other two fat-soluble vitamins, *viz.*, vitamin A and vitamin D, and is not

1. John Pryde, Recent Advances in Biochemistry, 1926, p. 242.
2. British Med. Jour., Feb. 6, 1926, p. 239.
3. John Pryde, Recent Advances in Biochemistry, 1926, p. 247.

destroyed by saponification with boiling alkalies and distillation at temperatures over 200° C.

Vegetable Acids.—These are organic acids, the chief of which are tartaric, citric, malic, oxalic and acetic. They exist in fresh vegetables and fruits either as free acids, or combined with alkalies as alkaline salts, and form carbonates in the process of digestion which help greatly in maintaining the alkalinity of the blood and other fluids. They also furnish a small amount of energy and heat by oxidation.

Mineral Salts.—The mineral salts, namely, chlorides, phosphates and sulphates of calcium, sodium, potassium and magnesium, as also some iron salts must be included in the diet, as they help in building up and repairing the tissues of the body. The chlorides as represented by common salt keep in solution the cells of the blood and other fluids, and the hydrochloric acid of the gastric juice is also derived from them. The phosphates of calcium, potassium and magnesium contribute largely to the formation of bone, and iron forms an important part of the colouring matter of the red blood corpuscles.

Water.—Water happens to be the medium through which all chemical changes with regard to the nutrition and repair of body tissues take place. It helps to eliminate the effete products, to maintain the body heat by evaporation and acts as a solvent and diluent of solid foods, so that they may be easily digested and assimilated in the system.

NUTRITIVE VALUE OF FOOD STUFFS.

The energy value of the food stuffs may be expressed as the heat produced during its combustion. The standard of this measure is the heat-unit or calorie. A calorie is the amount of heat required to raise the temperature of 1 kilogramme or 1 litre of water 1° C. or 1 lb. of water 4° F. The calories may also be expressed in terms of work, as heat is also a mode of motion. The heat-unit may be transformed into the metric work unit by multiplying it by 425, and into the foot-pound unit by multiplying it by 3,060.

In the body the combustion of carbohydrates and fat is complete, but protein is not completely oxidized, being largely excreted as urea from the body. Rubner after careful investigations estimates that during digestion 1 gramme of protein yields 4.1 calories, 1 gramme of fat 9.3, and 1 gramme of carbohydrate 4.1. The amount of energy expended by a man at rest in the form of heat and of the internal work of the various systems is 2,500 calories per day. According to Voit a diet yielding 3,000 calories is regarded sufficient for a man doing hard muscular work, but according to the investigations carried on during the late War 4,500 calories were supposed to be necessary for the maintenance of good health of the soldiers during training and in active service. Hence the field service ration was raised to 3 lbs.

STANDARD DIET.

While constructing ideal standard diets the daily loss of carbon and nitrogen has to be taken into consideration. A man weighing 70 kilogrammes or 11 stone excretes 20 grammes of nitrogen and 300 grammes of carbon in 24 hours. Assuming that proteins contain 16 per cent. of nitrogen, 125 grammes of proteins are required to supply 20 grammes of nitrogen. But according to Chittenden a little more than half the amount of proteins is advantageous both on the ground of health and economy. Mc Cay[1] has also found from experiments conducted on the metabolism of the natives of Bengal that 37.5 grammes of protein per day are sufficient to supply the needs of an average Bengali. Physiologists, however, do not agree to such a low protein diet, inasmuch as it does not allow any reserve for emergency calls upon the individual in the time of privation or severe illness, and for building up a resistance to the attacks of disease. Again from the studies of dietary scales of different civilized nations it appears that 90 to 100 grammes

1. Scientific Memoirs, Medical Department, Government of India No. 34.

of protein are consumed daily on an average by each individual. It can, therefore, safely be laid down that a diet containing not less than 100 grammes of protein per day for an adult weighing 70 kilogrammes is necessary for the people, especially for those whose daily life requires considerable muscular exertion.

After calculating the protein requirement it now remains to find out the amounts of fats and carbohydrates required per day. These two principles of the dietary are the chief sources of the supply of the carbon needed by the body and also of the energy. It has already been mentioned that an individual weighing 70 kilogrammes excretes 300 grammes of carbon, and therefore requires the same amount of carbon to replace the loss. 36 grammes of carbon are obtained from 100 grammes of protein, of which only two-thirds have undergone complete metabolism. Hence 264 grammes have to be obtained from fats or carbohydrates. The body cells are quite indifferent regarding the source of energy required by them as to whether they get it from fats or carbohydrates. But the digestive system is in no way indifferent to this supply. If all the energy equivalent to 264 grammes of carbon were derived from fat, all the fat will not be absorbed and will lead to nausea and flatulence. On the other hand, if the energy required was derived from the carbohydrates, a large quantity of them will have to be taken, and that will overload the stomach and intestines and will produce acidity and flatulence by undergoing fermentation. It should also be borne in mind that fat is not able to replace carbohydrate in its dynamic equivalent in protein sparing power.[1] In this direction 1 part of fat is not as efficient as 2¼ parts of carbohydrate.[1] Taking all these points into consideration it is necessary that some 60 grammes of fat which will yield 46 grammes of carbon should be included in the dietary and 540 grammes of carbohydrates to supply the remaining 218

1. Hutchison, Food and Principles of Dietetics, Ed. V, 1923, p. 28.

grammes of carbon. But a diet sufficient to have a fuel value of 3,000 calories should consist of 100 grammes of protein, 75 grammes of fat and 450 grammes of carbohydrates. Such a standard diet may be regarded as suitable for an individual of average build and weight, leading an active life, and doing a fair amount of work.

The following is a table for the standard diet required for a European weighing 150 lbs. :—

	Subsistence.	Ordinary work.	Hard, laborious work.
	oz.	oz.	oz.
Proteins ...	2.0	4.5	6.5
Fats ...	0.5	3.5	4.0
Crabohydrates ...	12.0	14.0	17.0
Salts ...	0.5	1.0	1.3

According to Church the following table is for the standard diet for an Indian weighing 105 lbs. :—

	Subsistence.	Ordinary work.	Hard, laborious work.
	oz.	oz.	oz.
Proteins ...	2.123	2.954	3.635
Fats ...	0.752	1.412	2.506
Carbohydrates ...	7.520	12.531	11.190

The above quantities are supposed to be dry or water-free food. Ordinarily solid food contains, on an average, 50 or 60 per cent. of water, so that in actual practice the quantities shall have to be doubled. Thus, the daily quantity of

dry food required by a man doing no work is about one-tenth ounce for each pound of his body weight, and one-seventh ounce by a man doing ordinary work. Women require about 10 per cent. less than men, and children under ten years of age need one-half of a woman's allowance, but require more food per unit of body weight and a higher proportion of proteins. At 14 years they require as much as a woman. But old people require a smaller quantity of food, as their physical activities are very much restricted and their power of assimilation is on the decline.

Brain workers need easily digestible food, in sufficient but not in large quantities, and preferably of animal origin. Again, habit, race and climate should be taken into consideration in selecting both the quality and quantity of a dietary. For instance, a largely vegetable dietary suits the constitution of an Indian and other tropical races better than an exclusively meat one ; while the contrary holds good in the case of Europeans and other races inhabiting the temperate and cooler climates.

Calculation of a Diet.—To calculate a diet the first essential point is to know the percentage composition of common foodstuffs, and then to employ the rule-of-three to determine the quantities of the proximate principles according to the standard diet. The following is a table showing the composition of the various articles of food :—

Articles of food.	In 100 Parts.			
	Proteins.	Fats.	Carbo-hydrates.	Salts.
Raw Meat ...	20.5	8.5	...	1.5
Cooked Meat ...	27.5	15.5	...	3.0
Salt Meat ...	30.0	2.0	...	20.0
Pork ...	10.0	50.0	...	2.0

Articles of food.	In 100 Parts.			
	Proteins.	Fats.	Carbo-hydrates.	Salts.
Fish ...	16.0	5 0	...	1.0
White Fish ...	18.0	3.0	...	1.0
Eggs ...	13.5	11.5	...	1.0
Milk (Sp. gr. 1030) ...	4.0	3.7	4.8	0.7
Butter ...	4.0	81.0	...	2.5
Cheese ...	28.2	31.6	...	4.2
Wheat ...	13.5	1.2	68.4	1.7
Wheat, Fine Flour ...	7.9	1.4	76.4	0.5
Bread (Wheaten) ...	8.0	0.5	50.0	1.5
Juar ...	7.67	2.77	67.26	...
Bajri (*Bajra*) ...	10.4	3.3	71.5	2.0
Barley-meal ...	10.5	2.2	72.8	2.6
Maize ...	9.5	3.6	70.7	1.7
Oatmeal ...	16.1	7.2	67.5	1.9
Rice ...	6.5	0.6	79.1	0.6
Rye Flour ...	6.8	0.9	78.8	0.7
Gram ...	21.7	4.2	59.0	2.6
Mung ...	22.7	2.2	55.8	4.4
Arhar ...	21.70	54.06	2.50	5.50
Urd ...	22.33	55.22	1.95	...
Masur ...	25.47	55.03	3.00	3.33
Peas (*Mattar*, dried) ...	24.6	1.0	62.0	2.9
Peas (*Mattar*, green) ...	7.0	0.5	16.9	1.0
Soy Beans ...	35.3	18.9	26.0	4.6

Articles of food.	In 100 Parts.			
	Proteins.	Fats.	Carbo-hydrates.	Salts.
Arrowroot ...	0.8	...	83.3	0.27
Sugar ...	...	...	96.5	0.5
Potatoes ...	1.5	0.1	23.0	1.0
Bananas (yellow) ...	1.3	0.6	22.0	0.8
Cabbage ...	1.8	0.5	5.8	0.7
Carrots (fresh) ...	1.1	0.4	9.3	1.0
Ground-nuts ...	24.5	50.0	11.7	1.8
Almonds ...	21.0	54.9	17.3	2.0
Walnuts ...	18.4	64.4	13.0	1.7

In England a diet containing 9 ounces of meat, 18 ounces of bread, 16 ounces of potatoes, 16 ounces of milk, 2 ounces of butter, and 3 ounces of oatmeal is considered quite sufficient; while in India a diet consisting of 4 ounces of meat, 24 ounces of wheat, 16 ounces of vegetable, 16 ounces of milk, 2 ounces of butter, and 3 ounces of *dal* is regarded quite liberal, and is generally taken by Sikhs.

Indian Sepoys on field service are supplied with a ration as follows:—

Atta (Wheat flour), or Rice	...	$1\frac{1}{2}$ lb.
Fresh meat (Only for meat-eaters)	...	4 oz.
Dal	...	3 „
Ghee	...	2 „
Goor	...	2 „
Potatoes	...	2 „
Salt	...	$\frac{1}{2}$ „

CONDITIONS REGARDING DIETS TO MAINTAIN HEALTH.

Even though food may be taken in due proportion of its necessary constituents it may fail to nourish the body sufficiently, unless the following conditions are also complied with :—

(*a*) **Digestibility.**—The digestibility of any kind of food depends upon its quality and its mode of cooking. Vegetable foods are ordinarily less digestible than animal owing to their containing a very large amount of indigestible cellulose.

(*b*) **Flavouring.**—Flavouring of food, if deficient or if not varied from time to time, may fail to invite a good appetite. Experience regarding prison and asylum dietary has shown that attention to varieties of flavouring improves noticeably the health of the inmates.

(*c*) **Uniform Quality of Food.**—Continued ingestion of a similar kind of food has commonly been known to impair the digestion. Hence perhaps the custom among Hindus of eating particular articles of diet on certain days of a week. The sameness cloys, and with variety more food is taken and a larger amount of nutriment is introduced.

Besides, there are a few other points equally important in reference to ingestion of food, which should also be taken into consideration.

1. **Time.**—The hours of meals should be fixed at due intervals and kept regularly. There must be an interval of from 5 to 6 hours between any two of them, so that the stomach may have at least an hour's rest after the products of gastric digestion have left it after physiologically fixed periods of four hours for active digestion. The hours observed by Indians generally with reference to their meals (midday and an earlier part of the evening) happen to be placed at injuriously long and unequal intervals. For men at work it is injurious to start their daily labour with an empty stomach ; they should,

therefore, have some sort of a light meal before commencing it. An empty stomach also will predispose to attacks of chill and fever.

2. **Mastication.**—Food must be properly masticated, and for the purpose must be taken in small mouthfuls.

3. **Ingestion of Water.**—Water should not be taken in large quantities either before or during a meal, as it dilutes the gastric juice, and thus harms its digestive properties and predisposes to attacks of dyspepsia and indigestion.

4. **Cooking of Food.**—A proper mode of cooking is also an essential factor, inasmuch as it makes the articles of food not only soft, tender, digestible and palatable, but also inviting to the eyes. The process of cooking specially at a high temperature kills almost all the germs of disease, and thus obviates a very common source of infection. The chief methods of cooking adopted are boiling, roasting, frying, and steaming.

Boiling helps the decortication of an indigestible coating of food materials. Boiled food is less tasty, but more digestible than when cooked in any other way. Meat should be plunged suddenly into boiling water and allowed to remain there for a few minutes, if it is desired to retain its nourishing substances within the mass. This makes it harden on the surface. This hard portion acts as a skin, and prevents juices of the meat escaping. If a rich broth is desired, the meat should be placed in cold water, and boiled slowly. By this process the meat extractives and all the natural juices pass out into the surrounding water, and the meat itself is left in a nearly tasteless condition, but it has still some nutritive value. Boiling for a prolonged period hardens the meat by overcoagulation of the proteins, and thus makes its fibres tough.

In the process of roasting meat is exposed to the direct action of a fire, and shrinks considerably due mainly to loss of water. The principle in roasting is the retention of nutritive juices by the formation of a coagulated layer on the

surface. Roasted meat is much more tasty than boiled meat, but does not digest so easily.

Frying consists in boiling the food in very hot fat or vegetable oil. Fried substances are often indigestible on account of the large amount of the oily matter, that penetrates into them.

Steaming is a good method of dealing with starchy foods. It is carried out by placing an article of food on a metal sieve which is then put in a pot of boiling water supported by pieces of a brick, so that only the steam reaches the article.

It may also be added that cooking utensils should be kept scrupulously clean and well tinned, especially if made of copper. As far as possible, boiling water should be used for washing them instead of dry earth which, though a potent source of infection, is commonly used in an Indian household. The floor and walls of a kitchen should be kept thoroughly clean, and washings and scraps of food should not be allowed to accumulate in it.

DISEASES CAUSED BY FAULTY DIETING.

1. **Cooking of Food.**—Badly cooked food usually causes indigestion.

2. **Quantity of Food.**—An excess of it brought on through frequent feeding, or ingestion of an unusually large amount of it at a time, will bring on attacks of dyspepsia, constipation and irritative diarrhœa; on the other hand, if its quantity be less than would be needed for proper nourishment, the health of an individual may generally fail on account of debility, prostration, and anæmia.

3. **Quality of Food.**—Ingestion of food containing proteins, fat and carbohydrates in disproportionate quantities is liable to bring about serious digestive troubles. For instance, an excess of proteins will cause enlargement of the liver accompanied by dyspepsia, gout and albuminuria; the "banting" system of cure for obesity is, however, based

on an almost exclusive use of protein dieting. An excess of consumption of starchy and fatty foods, on the contrary, tends to produce corpulence, dyspepsia, flatulence and acidity, and delays nitrogenous metamorphosis. A sedentary habit largely abets an injurious accumulation of adipose tissue.

Generally speaking, a deficiency of nitrogenous constituents leads to a loss of tissue proteins through oxidation causing loss of weight. A deficiency of carbohydrates or of fats can, however, be borne better for some time but a simulataneous defect of both will very soon lead to a state of injurious malnutrition as will be evidenced by the onset of such debilitating diseases as scrofula and tuberculosis. Owing to the scarcity of food during the last Great War the poorer classes of the people in Germany, Russia, Roumania and also in other countries had to consume for a prolonged period a diet consisting largely of carbohydrates, very little proteins and almost no fat, and yielding on an average 1,400 to 1,600 calories per day. They suffered from a disease known as War Œdema which generally resembled the symptoms of parenchymatous nephritis.

Vitamins are essential to the growth and maintenance of normal development. Their absence from food stuffs produces certain diseases aptly called deficiency diseases. Thus a lack of a sufficient quantity of vitamin A from the diet arrests the development of growth leading to the loss of body weight and ultimately death, but the most characteristic result is the development of xerophthalmia, which may cause blindness. A diet deficient in vitamin B generally causes polyneuritis or beri-beri. Professor Plimmer[1] suggests that the fundamental effect of vitamin B lack is to produce atony of the gut, and that polyneuritis is possibly due to absorption of some toxic products of putrefaction. It is also suggested that partial lack of vitamin B in the dietary may be responsible for retardation of growth or for failure of the

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1. Brit. Med. Jour., Feb. 6, 1926, p. 239.

nervous system to develop properly.[1] Some believe that a deficiency of this vitamin especially in adolescence may tend to the development of dementia præcox.

The absence of vitamin C causes loss of energy, pains in the joints and limbs, and eventually scurvy, as is evident when fresh fruits and vegetables are excluded from a diet for a prolonged period.

The withdrawal of vitamin D from a dietary especially of children will produce a disease called rickets, the characteristic feature of which is a disturbance of calcium and phosphate metabolism which results in a deficient calcification of the long bones, so that they bend and are easily fractured. The teeth appear late, the liver and spleen are enlarged and the general nutrition is also very poor. Osteomalacia may appear in grown up persons owing to want of this vitamin.

A diet lacking in vitamin E produces disturbances of reproductive functions and leads to sterility.

Mineral salts are very necessary for maintaining the general metabolic balance of the body. It is said that death will ensue within thirty days if the supply of the mineral salts was stopped even if all the other normal constituents of a normal diet were provided.[2]

A deficient quantity of water by preventing free elimination of waste products from the system is liable to bring on diathetic complaints like rheumatism and gout.

ARTICLES OF FOOD.

ANIMAL FOODS.

These contain much digestible matter, chiefly proteins, a considerable quantity of fat, in some foods carbohydrates, in addition to water and mineral salts. Being thoroughly digested they leave but little residue in the intestines. For convenience of description they are classified as meat, fish, eggs and milk.

1. J. J. R. Macleod, Physiology and Biochemistry in Modern Medicine, Ed. V, 1926, p. 808.

2. Finch, Dieto-therapy, Vol. I, p. 255,

MEAT.

The flesh of many animals is eaten as an article of food by man in different parts of the world, but the animals from which it is derived in India are goats, sheep and buffaloes. The consumption of cow flesh is religiously forbidden to the Hindus, while pork is condemned similarly by the Musulmans and Jews. Meat contains proteins, fat and salts. The proteins contained in it are myosin, alkali and serum albumin, a globulin derived from the blood; and gelatin formed in the process of cooking from the connective tissue coat of the muscle fibres, vessels and nerves. About thirteen per cent. is duly assimilated. The amount of fat varies in different kinds of meat. It solidifies after death, and consists of stearin, palmitin and olien. The salts of meat are chiefly the chlorides and phosphates of potassium. Besides these three principal constituents, some extractives are also contained in the composition of a meat dietary derived from the muscles, and are said to stimulate digestion by imparting flavour and taste, though they have no nutritive value.

Bones form about 15 per cent. by weight of the meat marketed ordinarily and contain albuminoids, fat and mineral salts. With them soup is largely made, and from their marrow a highly nutritive form of food is prepared and used largely in the treatment of anæmia.

Digestibility of Meat.—Meat is one of the most nutritious articles of diet, as about 95% of it is absorbed into the blood leaving 5% as a residue of unabsorbed organic matter in the intestine. During the process of digestion in the stomach the muscle fibres swell up, become softened and greyish-yellow in colour and lastly form into a pulpy mass. These changes depend upon the condition of the connective tissue holding the muscle fibres and the amount of fat present in the meat. The method of cooking has also a great influence on the digestibility of meat. Thus Jessen[1] has found from

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1. R. Hutchison, Food and Dietetics, Ed. V, 1923, p. 66.

experiments on man that $3\frac{1}{2}$ ounces of beef disappear completely from the stomach in the following different times depending on the process of cooking :—

Raw beef	... 2 hours.
Half boiled beef	... $2\frac{1}{2}$ hours.
Wholly boiled beef	... 3 hours.
Half roasted beef	... 3 hours.
Wholly roasted beef	... 4 hours.

He has also found that the same quantity of raw meat leaves the stomach in exactly the same time as raw beef, while, owing to a large quantity of fat interposed between the fibres, the same quantity of raw pork takes 3 hours for complete digestion. It is apparent from the above findings that raw or underdone meat is an article of diet easy of digestion during illness, when the stomach is weak and in an irritable condition.

Diseases caused by Bad and Unsuitable Meat.— Putrid meat produces symptoms of ptomaine poisoning consisting of those of acute gastro-intestinal irritation, such as nausea, vomiting, abdominal pain, diarrhœa, and general prostration. Other poisonous symptoms are manifested through consumption of the meat of animals that have fed themselves on poisonous plants, or have been drugged with irritants, such as arsenic and antimony prior to their slaughter. The use of the meat of animals that have suffered from infectious or acute inflammatory diseases must be entirely prohibited.

Microbes or parasites that ordinarily find access into the muscles of animals are destroyed in the process of cooking but the toxins, if present in large quantities, may yet give rise to symptoms of poisoning. The parasites that ordinarily infect the animals are Tænia solium, Tænia mediocanelata and Bothriocephalus latus. When the meat of such animals is not properly cooked, the undestroyed cysticerci of the parasites are ingested, undergo certain changes and develop eventually

into tapeworms in the small intestine of man. There is another parasite named Trichina spiralis, infesting the muscles of pig, which causes a disease known as trichiniasis in man by eating partly cooked pork or sausages infested with this parasite. The symptoms are diarrhœa and loss of appetite followed by fever, severe muscular pains, contractions and coma. Death may occur in a few weeks. The early symptoms, sometimes, simulate enteric or rheumatic fever.

Inspection of Animals and Meat.—Animals, the flesh of which is ordinarily consumed by human beings, should be inspected before being slaughtered for the purpose. The animal should not be too young or too old, and should have a normal weight. The age is ascertained from the teeth and the number of rings in the horns. It should be remembered that the latter may be filed by the dealers. The weight of a live animal may be determined by the formula $\frac{2}{3}(5\ L \times G^2)$ lbs., where L represents the length of the trunk measured from just in front of the scapulæ to the root of the tail, and G represents the girth or circumference taken just behind the scapulæ. To the result thus obtained 1/20 may be added in the case of very fat animals, or may be deducted in the case of very thin ones. Animals in India are generally smaller and weigh less than in England and other European countries. An ox in India weighs on an average from 350 to 400 pounds, whereas an ox in England weighs from 600 to 1,200 pounds. A full-grown sheep weighs in India from 20 to 35 pounds and from 60 to 90 pounds in England.

Signs of health like free and active locomotion and a well-nourished body, bright eyes and glossy skin should particularly be looked for. Besides, it should also be noted that the breath should not be offensive, the mouth and nostrils should not be discharging, and both circulation and respiration should be tranquil. A sick animal, on the contrary, moves slowly and has a rough skin, dry nostrils covered with foam, dull heavy eyes and a protruding tongue, and

evinces generally symptoms of laboured breathing. It should be specially noted that tuberculosis is commonly met with amongst cattle, pigs, poultry, and rarely sheep, and as it is easily transmissible to human beings, it is necessary to detect its presence. Its presence may be ascertained by an examination of cervical or abdominal glands likely to be found inflamed and enlarged, and of the udders in the case of cows, which will be found similarly inflamed. In doubtful cases a definite diagnosis can be made by injecting Koch's "tuberculin," and by observing the resulting reaction.

Besides inspecting the animals, it is also necessary to inspect the meat. Good meat should be firm and elastic and of bright red colour (except in the case of pork and veal) and marbled with fat. It should not pit on pressure, nor should it crackle. There should be no hæmorrhages in its substance, as these are indicative of acute disease. The juice exuding from the muscle should be red in colour and acid in reaction. The odour should be fresh and pleasant. Putrid meat is pale and soft and later on greenish, giving off an offensive smell, and alkaline or neutral in reaction. It is always safe to thrust a long-bladed knife deep into the flesh, and to see if the blade emits an unpleasant smell. The fatty covering of healthy meat should be firm and pale yellow in colour and free from blood, while suet fat should be hard and white. The ribs, if found attached to meat, should always be examined for pleuritic adhesions, while the attached pleuritic membrane should also be examined for the presence of tuberculous nodules commonly known as "butcher's grapes or kernels." The lungs should be examined for the presence of inflammation and abscesses, the liver for the presence of distoma or liver fluke, the muscles for teniæ and trichinæ and the mouth, stomach and intestines for evidence of specific cattle diseases. Lastly, the mesenteric and pelvic glands should also be examined for the presence of caseating masses.

Preservation of Meat.—Meat is usually preserved by drying, salting, and by the application of cold or heat.

Meat can be dried by exposure to the sun or to fire. The flesh thus treated loses much of its water, becomes desiccated and inhibits the growth of putrefactive bacteria. Smoking is very often combined with drying in preserving meat. Salt is a very good chemical as a preservative of meat, though its nutritive value diminishes very much. The meat can be smeared over the surface with salt, or can be pickled in brine, which usually consists of 1 part of saltpetre, 32 parts of salt and 2 parts of sugar.

The fact that cold prevents the growth of bacteria is made use of in preserving meat, especially when it has to be shipped long distances. The meat may be kept frozen or may be kept in a chamber, the temperature of which is at or just below 0° C. Frozen meat does not keep long after it is once exposed to the ordinary temperature of the air.

Heat as a preservative is used when meat or any other article of food has to be canned. The meat is sealed in tins, which are then subjected to steam under pressure at 115° C. for an hour or two. The contents of the tins expand and cause bulging. A small opening is, therefore, made in the lid to permit of the escape of air, and then the opening is sealed with solder. The tin is then heated for another hour to complete the sterilization. Owing to the partial vacuum caused during sterilization, the ends of the tins are slightly depressed. The presence of gases resulting from putrefaction bulges out the ends of the tins. Such a tin will emit a hollow sound when struck with a mallet and a splashing sound will be heard, when it is shaken. On opening it the gelatin is found in a liquid state. Tinned foods may become poisonous from the absorption of metal; hence the tins should be condemned if on opening they show a blackened appearance due to the action of sulphuretted hydrogen formed prior or subsequent to sterilization. The tin, in which food is preserved, should never contain more than 1 per cent. of lead. The acid foods are more likely to be affected by lead or any other poisonous metal.

FISH.

In India fish is extensively used as an article of diet by people inhabiting Bengal and the coastal towns. Fish consists mainly of two nutritive constituents, *viz.*, protein and fat. According to the proportion of fat present, fish may be classified as " lean " and " fat ". Lean fish contains less than 2 per cent. of fat, while fat fish contains 2 to 5 per cent. or more of fat. Like meat fish is easily digestible and almost completely absorbed, as 95 % of the total solids, 97 % of the protein and 90 % of the fat enter the blood. Hence fish constitutes an excellent article of diet, especially for invalids and convalescents.

Fish was formerly considered to be a very valuable article of diet for brain-workers on the presumption that phosphorus was essential for such men and that it was largely present in the fish ; but there is no justification in either of these beliefs. The belief that fish possesses aphrodisiac properties is also erroneous, and not borne out by facts. Pereira has pointed out that maritime populations which use fish to a large extent are not specially prolific.[1]

Fish must be eaten fresh, and as early as possible after being caught. Fish is at its highest state of perfection just before spawning, and is then said to be " in season ". During spawning it loses its store of fatty matter, and becomes poor, thin, watery and flabby. It is then said to be " out of season," and takes time to recover its condition.

Fresh fish is firm, stiff and free from any disagreeable odour, and its tail does not droop if held up horizontally. The eyes are prominent and full with dark pupils, the gills are bright and red and the scales are full, firm and not easily detachable or rubbed off. In warm climates fish rapidly decomposes. There is also a well-known proverb that fish should not be eaten in those months in which there is no " r." Thus in the

1. R. Hutchison, Food and Dietetics, Ed., V, 1923, p. 84.

months of May, June, July and August it should not be eaten, as it is likely to get decomposed rapidly owing to heat.

A putrid fish has dull, grey and sunken eyes and grey slimy gills, is inelastic and emanates a disagreeable odour, and its skin peels off easily. If eaten, when decomposed, it produces symptoms of acute gastroenteritis, *viz.*, vomiting, diarrhœa and prostration. Fish is also liable to certain parasitic infection, for instance, the cysticercus of Bothriocephalus latus. Mussels and Oysters growing in sewage-polluted water have been known to convey the germs of cholera and enteric fever. They are also sometimes responsible for giving rise to symptoms of gastro-intestinal irritation simulating a choleraic attack.

Fish can be preserved by various methods, such as drying, salting, smoking, pickling and canning, but these methods modify its flavour to a great extent.

Salted fish, which is known as "Bombay ducks" or *Bomblas*, is relished very much, and is generally eaten with rice.

EGGS.

Hens' eggs are usually eaten as food, though ducks' eggs and those of sea-fowls are also used in certain places. The egg consists of 12 parts of shell, 58 parts of white and 30 parts of yolk. The shell consists chiefly of carbonate of calcium. The white consists of 12.6 per cent. of protein in the form of egg albumin, 0.25 per cent. of fat, 0.59 per cent. of salts (chiefly sodium salts and chlorides) and 85.7 per cent. of water. The yolk consists of 16.33 per cent. of nitrogenous matter (of which 16 2 per cent. is globulin or vitellin and 0.13 per cent. is other nitrogenous matter), 31.75 per cent. of fat, 1.09 per cent. of salts (mainly of potassium, iron and phosphorus) and 50.9 per cent. of water. The yolk contains vitamins, especially fat-soluble A and water soluble B.

Eggs are said to be the safest of all animal foods, as they are not liable to convey disease or contain harmful properties,

There is no known infection of the hen transmissible to man through its egg. It must, however, be borne in mind that owing to idiosyncrasy even a small particle of egg may produce what is known as "anaphylaxis," the chief symptoms being urticaria, vomiting, syncopy and even coma.

The time taken up by eggs for complete digestion in the stomach depends largely upon the form in which they are eaten. The following is a table showing the different times when two eggs cooked in different ways, and eaten by a healthy man leave the stomach[1] :—

Lightly boiled ...	$1\frac{3}{4}$ hours.
Raw ...	$2\frac{1}{4}$ hours.
Poached and 5 grammes of butter ...	$2\frac{1}{2}$ hours.
Hard boiled ...	3 hours.
Omelette ...	3 hours.

Raw eggs being almost bland do not stimulate gastric secretion, nor do they excite the stomach movements. Hence they are not digested in the stomach but pass into the intestine, where digestion is completed. They are, therefore, very beneficial to those, whose stomach is weak and irritated owing to chronic illness. Every child in weak health should get from one to two raw eggs per day, preferably mixed with milk. An adult, who has tuberculosis or is predisposed to get it, should take from four to six raw or half-boiled eggs in twenty-four hours. Boiled eggs coagulate the albumin, and hence are difficult to digest. One egg yields 70 Calories of energy, and is equivalent in nutritive value to $4\frac{1}{2}$ ounces (half a tumbler) of good milk or $1\frac{1}{2}$ ounces of fat meat.

An average sized egg of a hen weighs about 2 ounces. A fresh egg should have a translucent centre when looked through in front of a candle or light, but in a stale one translucency is more noticeable at its top, when held vertically, owing to

1. Benzodt, Deut, Arch, Klin, Med., 1893, p. 535 ; R. Hutchison, Food and Dietetics, Ed. V, 1923, p. 157.

the presence of gases of decomposition. A good fresh egg will sink in a ten per cent. solution of common salt, and a stale one will float.

Eggs can be preserved by covering their shell with oil, gum or wax, or with insoluble lime compounds. They can also be preserved by packing in salt or saw-dust. Eggs are broken out and dried by spreading them over the surface of a slowly revolving cylinder heated with a current of warm air. The eggs thus prepared are called desiccated eggs, and are largely used by bakers and others who use eggs in large numbers. They have the advantage of keeping under conditions, where fresh eggs are not available.

CHAPTER XII.

FOOD—(*Continued*).

MILK.

MILK is the fluid secreted by the mammary glands of female mammals, and is intended for the rearing and nourishment of their young. It is a typical example of a whole perfect food, as it contains all the constituents of a standard dietary in their nutritive proportions. Milk constitutes the staple diet for children till about the age of two years, but practically it is unable to stand as the only article of diet for healthy adults, seeing that, to derive the requisite nourishment a very large quantity of it, approximately nine pints, will have to be consumed. But such a large quantity containing, as it will, an enormously injurious amount of water cannot be conducive to healthy digestion. It, however, forms a very suitable article of diet for sick persons, especially for those suffering from weak digestion. As a nutritious article of diet milk plays an important role in the dietary of vegetarian Hindus. The usual custom is to take it early in the morning and just before retiring to bed. It should not be taken as a drink at meals, because it retards the process of digestion, and favours fermentation. All forms of milk are emulsions of fat containing proteins, carbohydrates and salts in solution in water.

The proteins of milk consist of caseinogen, lactalbumin, and lactoglobulin. Traces of nuclein, fibrin and mucin are sometimes found. The chief of these is caseinogen, which is held in solution by calcium phosphate, and belongs to a group of nucleo-albumins. It is precipitated by saturation with salts or by addition of acids, such as acetic acid. It is coagulated and split up into insoluble casein by the action of rennet enzyme. It is not affected by heat. Lactalbumin is present in milk in small

quantities, though much more abundant in colostrum. It contains sulphur but no phosphorus. It is coagulated by heat at a temperature of 70° C., but not by dilute acids. Lactoglobulin is also present in traces but comparatively more in colostrum. It is insoluble in water, but dissolves in a weak solution of salt and coagulates at a temperature of 75° C.

The carbohydrate constituent of milk is called milk-sugar or lactose, a disaccharide, $C_{12}H_{22}O_{11}$. It is found only in milk and nowhere else in nature, but it may be found in the urine of a suckling mother. It undergoes fermentation under the influence of enzymes secreted by certain micro-organisms especially *Bacillus acidi lactici*, and is split up into glucose and galactose and ultimately into lactic acid. The acid thus formed precipitates a portion of caseinogen and renders the milk sour. This change, however, will not occur, if the milk were kept in a closed sterilized vessel. The same fermentative changes may be brought about by bacteria in the intestine, giving rise to diarrhœa.

The fat of milk exists in the form of minute oil globules suspended in milk plasma, and consists of different neutral fats, the chief of which are olein, palmitin and stearin. Besides these, small quantities of lipoids, such as lecithin, colesterin and lipochrome (a yellow fatty pigment) are also present. Milk fat also contains fat soluble A vitamin, which promotes growth.

The mineral salts of milk consist chiefly of phosphates and chlorides of calcium, potassium and sodium. In fact almost all the salts necessary to the growing body are present except iron, which is met with only in traces. Stockmann[1] has proved that five pints of milk would be required every day to supply the amount of iron necessary for a full grown man.

In addition to these constituents milk contains all the three varieties of vitamins, *viz.*, fat soluble A, water soluble B

1. Jour. of Phys., 1895, Vol XVIII, p. 484 ; Hutchison, Food and Dietetics, Ed. V, 1928, p. 111.

and water soluble C. The first two retain their properties, even when milk is kept for some time, or is exposed to heat or to a process of drying. The last, which has an antiscorbutic property is present only in fresh milk. It deteriorates in time, and is affected by drying or heating. Hence it is very essential to give orange or lemon juice to infants, brought up by artificial feeding.

The chief sources of milk and the average composition of each of its variety are as follows:—

Kind of Milk.	Sp. Gr.	Total Solids.	Proteins casein-albumin.	Fats.	Carbo-hydrates, lactose.	Salts.	Water.
Mare's Milk ...	1027	12.60	1.03-1.26	3.81	6.20	0.30	87.40
Cow's Milk ...	1032	12.83	3.02-0.53	3 69	4.88	0.71	87.17
Buffalo's Milk .	1032	18.59	5.85-0.25	7.47	4.15	0.87	81.41
Goat's Milk ...	1032	14.29	3.20-1.09	4.78	4.46	0.76	85.71
Ass's Milk ...	1023-35	10.36	0.67-1.55	1.64	5.99	0.51	89.64
Human Milk...	1035	9.22	1.24-0.75	1.21	5.67	0.35	90.78

Milk is rapidly coagulated by the action of hydrochloric acid and rennin or rennet of the gastric juice. This coagulum or curd sets at first into a solid clot formed by the precipitation of casein and fat entangled in the curd. The clot afterwads shrinks and presses out a clear, yellowish liquid, known as whey. Owing to a small percentage of caseinogen in human milk the curd formed in the stomach is much less firm, and takes the form of a loose flocculent mass. The density of the clot depends upon the amount of casein and lime salts contained, and upon the degree of acidity of the gastric juice. The curd is digested by the pepsin of the gastric juice and, later by the trypsin of the pancreatic juice in the intestine. It is then fit to be absorbed in the blood. A pint of milk ordinarily yields 400 to 450 Calories. It should,

however, be remembered that the clotting of milk is not necessary for its digestion, for digestion will be completed in the intestine, even if clotting is prevented from occurring in the stomach by some previous device. It has also been found that milk is digested in the intestine in cases where the stomach has been removed for some disease.[1]

By experimenting on a healthy individual it has been ascertained that a glass of milk leaves the stomach in about 2 hours, and a pint of milk in about $3\frac{1}{2}$ hours. The duration of its stay in the stomach depends upon the condition of milk. Thus 602 c.c. (rather more than a pint) of raw milk or skimmed milk leave the stomach in $3\frac{1}{2}$ hours. The same quantity of sour or butter-milk leaves the stomach in 3 hours and that of boiled milk in 4 hours.[2]

Ordinarily cow's milk is largely used by human beings, but it contains a larger amount of casein and salts as compared with human milk; while it contains a lesser amount of the carbohydrate as represented by the proportion of milk-sugar in it. Thus during the process of digestion owing to a larger quantity of casein, it is likely to curdle more easily and produce indigestion. If it is used for infants under 9 months of age, the addition to it of a little water, milk-sugar and fat is necessary. Barley or lime water may also be added to it to help the formation of loose flocculent curd that is more easily digestible. Cow's milk differs in composition according to the age and the race of the cow, the kind of fodder used and period in relation to calving.

Besides cow's milk buffalo-milk, which is richer in fat, is used for human consumption. Ass's milk is very akin to human milk in composition, and is, therefore, largely used as its substitute. Infants in India, when artificially fed, are given ass's or goat's milk, whichever is more easily procurable.

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1. R. Hutchison, Food and Dietetics, Ed. V, p. 120.
2. *Ibid.*, p. 122.

Preservation of Milk.—The following methods are usually adopted for preserving milk from fermentation and decomposition :—

1. Boiling
2. Sterilization.
3. Pasteurization.
4. Drying or Desiccation.
5. Condensation.
6. Addition of Antiseptics.

1. **Boiling.**—This is a method commonly adopted in Indian houses for preserving milk for a certain length of time, say 12 to 24 hours. During the process of boiling milk undergoes certain changes which depend upon the degree of heat and the length of exposure. When milk is gradually heated in an open vessel to a temperature of 60° C., a thin scum consisting of casein, lactalbumin and lime salts entangled in fat forms on the surface. If this scum is removed, it again forms. No further changes, physical or chemical, are noticed, when milk is heated to a temperature of 62.8° C. for half an hour. The following changes are, however, observed when milk is slowly raised to a boiling temperature of 97.8° C. or more :—

(*a*) The taste is altered probably owing to the expulsion of gases.

(*b*) The colour becomes brownish owing to burning or caramelisation of a certain portion of the lactose.

(*c*) Proteins and other nitrogenous derivatives are decomposed and the fine emulsion of fat globules is disturbed, so that cream does not rise to the surface.

(*d*) The organic phosphorus is diminished, and the inorganic one is increased.

(*e*) Calcium and magnesium salts are precipitated.

(*f*) Milk ferments are destroyed.

Boiled milk is found to coagulate less slowly and to form a softer and more flocculent clot than raw milk. Hence

it is rendered easy of digestion, but it is apt to cause constipation, as it contains comparatively few bacteria, and is, therefore, less irritating to the intestines.

2. **Sterilization.**—This is accomplished by raising the temperature of milk to 100° C., and then maintaining it at that temperature for fifteen minutes in a closed sterilized vessel, which is then hermetically sealed at the boiling temperature. But in order to destroy the highly resistant sporing micro-organisms sterilization has to be effected by heating under pressure to a temperature of 115° C. to 125° C. Its disadvantages are that it alters the taste of the milk, and renders it dark owing to caramelisation of the milk sugar.

3. **Pasteurization.**—There are two processes of pasteurization of milk, *viz.*, "holder" process and "flash" process. The holder process consists in keeping milk at a temperature of 145° F. to 150° F. for a period of thirty minutes, and cooling it immediately afterwards to a temperature of not more than 55° F. This process is recommended by the Ministry of Health of England, as it destroys all pathogenic bacteria and 98 to 99% of the other bacteria. The flash process consists in rapidly heating milk to a distinctly higher temperature than 150° F. only for a few minutes, with the result that portions of milk are overheated, if not burnt, and pathogenic organisms present in milk are not destroyed owing to the rapidity with which the milk passes through the sterilizer, and owing to the consequent irregular temperatures. This process, therefore, is not considered satisfactory. Pasteurization if carried out properly, renders milk safe, and does not appreciably affect its nutritive value. But it does not keep the milk well for more than three or four days, as putrefactive or sporulating bacteria are not destroyed during pasteurization, though the lactic acid bacillus is destroyed.

According to the orders of the Ministry of Health of England the following conditions have to be fulfilled before a licence is issued to any one for selling pasteurized milk :—

(*a*) The milk should be pasteurized in a suitable and approved pasteurizer according to the " holder " process.

(*b*) The milk should not be heated more than once, and should not be otherwise treated by heat.

(*c*) Every vessel containing the milk should be suitably labelled with the words 'pasteurized milk' and the day of pasteurization.

(*d*) The milk, on bacteriological examination, should show not more than 30,000 bacteria per c.c., and no B. coli in 1/10 c.c.

4. **Drying or Desiccation.**—This consists in passing the milk between two revolving steam heated steel cylinders. The milk is spread in a thin film over the outer polished surface of the cylinders, when water of the milk is instantaneously evaporated, and the film of dried milk left is scraped off by sharp knife blades. This dried milk is then passed through a sieve, and reduced to a fine granular powder. Another method of drying milk consists in spraying the fresh milk into a warm vacuum chamber, where the milk is almost immediately deprived of its water, and the resulting powder falls to the floor of the chamber. Dried milk easily dissolves in water, the solution resembling fresh milk. It keeps well, and is very convenient for transport. The only drawback is that the antiscorbutic vitamins are diminished to some extent.

Dried milk sold under the commercial name of " trufood " is condensed in vacuo and converted into powder by being sprayed under very high pressure in a fine stream into a chamber, in which there is a current of warm, dry air, which at once converts the sprayed condensed milk into an extremely fine creamy white powder at a temperature of about 60° C. to 70° C. None of the solids are thereby changed, but the casein is in a very fine state of subdivision, and coagulates into softer clots than ordinary cow's milk does, or even than other kinds of dried milk do. This dissolves readily and completly

in cold water, and is found to respond to the usual tests for enzymes or fermants and vitamins.[1]

5. **Condensation.**—This is a process by which the watery portion of milk is evaporated under diminished pressure by gradually heating at a temperature of 55° C. (131° F.) to 65° C. (149° F.), so that it is reduced to one-third of its original volume. The milk thus prepared is known as condensed milk, and is imported into India on a large scale. It is prepared either from whole or skim milk, and may or may not be sweetened with cane sugar. It is then filled in tins, which are hermetically sealed and heated to a temperature of 280° F. to render it completely sterile. A tin of condensed milk must be used as soon as possible after it is opened, otherwise the milk is liable to undergo putrefactive changes. Condensed milk prepared from skim milk should not be given to infants, as it generally causes malnutrition, resulting in rickets, atrophy and emaciation.

6. **Addition of Antiseptics.**—Antiseptics, such as salicylic acid, boracic acid, borax, boroglyceride, sulphurous acid and formaldehyde are largely used as preservatives of milk in European countries, but their use must be prohibited as they are harmful to health. Hydrogen peroxide is added to milk to preserve it, but it destroys the water soluble B vitamin, and thus deprives the milk of its antiscorbutic properties. Milk treated with oxygen and carbon dioxide keeps quite good for a very long time, and does not alter in taste. It is first heated to a temperature of 150° F., and then aerated with a mixture of oxygen and carbon dioxide. Milk thus treated is again heated twice to the same temperature, each time for a period of half an hour.

Adulteration of Milk.—The adulteration of milk in India has become so proverbial that it is almost impossible to obtain pure and fresh milk. The most common adulterant

1. Medical Annual, 1928, p. 296.

is the addition of water varying from 20 to 60 per cent. Sweet substances, such as *batasas*, molasses, treacle or sugar are added to raise the specific gravity and thus disguise watering. A large part of the cream is very often removed, and water is then added to make up the normal specific gravity. The addition of skim milk to whole milk is also a form of adulteration difficult to detect. Thickening agents, such as starch, flour, gum, dextrine and arrowroot, are, sometimes, added to milk. Annatto, a vegetable colouring matter, is occasionally added with the object of concealing skimming or watering or to make the milk look richer.

Analysis of Milk.—The milk of cows and buffaloes is largely used in India. It is difficult to give the standard composition of milk for the whole of India, as the breeds vary in different parts of the country and consequently the amount of milk given by them. Dr. Joshi, of Bombay, gives the following as the average percentage composition of cows' and buffaloes' milk :—

...	Specific Gravity.	Total Solids.	Fat.	Solids not Fat
Cows' Milk ...	1030.87	13.9	4.85	9.04
Buffaloes' Milk ...	1028.87	17.36	7.62	9.66

It would appear from the above figures that the amount of fat in the milk of Indian cows and buffaloes should not fall below 4 and 5 per cent., respectively. Thus it is also apparent that the percentage of fat in the milk of Indian cows is higher than in that of European cows.

Physical Characteristics.—Pure milk, when placed in a glass vessel, should be quite opaque, white in colour, and should have no deposit at the bottom. It should have a sweetish taste but no smell. After standing for a while, a layer of cream should form on its surface, which should yield from 8 to 12 per cent. of cream.

Chemical Examination.—The chemical examination of milk consists in ascertaining its reaction, specific gravity, total solids and fat contained in it.

Reaction.—In reaction fresh milk is generally amphoteric, turning blue litmus red and red litmus blue, owing to the presence of both

acid and alkaline salts. The strongly acid reaction shows that lactic o butyric acids have developed owing to the action of micro-organisms. The milk is strongly alkaline, if the cow is ill, or if much colostrum, or sodium carbonate has been added to it.

Specific Gravity.—The specific gravity may be taken either with a hydrometer, a Westphal balance or with a specific gravity bottle. At a temperature of 60° F., the specific gravity of milk varies, as a rule, from 1028 to 1034. It is lowered by the addition of water, and raised by the removal of fat. The specific gravity falls 1° for each rise of 10° F. above 60° F., and at 60° F., there is a loss of 3° of specific gravity for every ten per cent. of water added.

Total Solids.—These are estimated by taking 2 c.c. of the milk in a flat shallow dish of known weight, and evaporating it to dryness over the water-bath and then in the water-oven for about half an hour. If the dish is now weighed with the residue, the increase in weight is the amount of total solids in 2 c.c.

Fat.—The determination of fat is very important. The chief methods that are adopted for estimating the amount of fat are Leffmann-Beam process, Werner-Schmidt process and Adam's process.

Leffmann-Beam Process.—For this process a special set of graduated flasks and a special centrifugal machine are used. Into one of these flasks 15 c.c. of the milk are introduced by means of a pipette, and then 3 c.c. of a mixture containing equal parts of amyl alcohol and strong hydrochloric acid, and these are thoroughly mixed. Then 9 c.c. of strong sulphuric acid are poured in slowly, 1 c.c. at a time, shaking after each addition. The flask is then filled up to the zero mark with a hot and freshly-prepared mixture of one part of sulphuric acid to two parts of water. It is then placed in the centrifugal machine. and centrifugalized for at least two minutes. On stopping the machine, the fat will be seen to have separated out as a layer on the surface, and the percentage is read off, each graduation representing 0.1 per cent. of fat by weight.

Werner-Schmidt's Method.—This is a wet extraction method, and is specially suitable for sour milk. It consists in taking 10 c.c. of the milk in a graduated Stoke's tube, and adding strong hydrochloric acid to the 20 c.c. mark, and heating until the mixture turns a dark brown colour. The tube and its contents are cooled in water, and ether is added to the 50 c.c. mark. The tube is firmly corked, and the contents are well mixed by inverting slowly ten to twelve times, and the fat is extracted. The tube is set aside to allow the ether to separate and become clear. 10 c.c. of the ether are taken and evaporated in a

weighed platinum dish. The dish is dried, cooled and weighed. The increase of weight is the weight of fat dissolved in ether.

Adam's Process.—This consists in the use of a strip of Adam's fat-free paper to absorb a definitely weighed quantity of milk. The paper is then rolled up into a coil, dried in the water-oven for two hours, and the fat is extracted by ether in Soxhlet apparatus.

Cane Sugar.—The presence of cane sugar is found by adding a few drops of hydrochloric acid and 0.1 grain of resorcin to 10 c c of the milk, when a rose-red colour is produced.

Starch.—The presence of starch can be detected by adding a small quantity of a solution of iodine in potassium iodide to the whey, when a blue colour is produced.

Microscopic Examination.—When seen under the microscope, the normal constituents of milk are round oil globules of various sizes in an envelope and a little epithelium. The abnormal constituents are pus cells, casts of the lacteal tubules and epithelium in large amount. The added matters may be dirt, starch grains, etc.

Bacteriological Examination.—For the bacteriological examination of milk samples should be collected with the greatest care A wide-mouthed bottle with an accurately fitting glass stopper and having a capacity of about a pint should be used for collecting the milk. If milk is to be taken from a cow, the udders and teats of the cow should be carefully washed, and the milker should wash and thoroughly disinfect his hands. The bottle and the stopper should be sterilized. The milk should be milked direct into the bottle, and the stopper which was held by another person should be inserted immediately. If the sample has to be taken from the pails of mixed milk, the milk should be well stirred before the sample is taken, as there are more bacteria in the cream and the sediment than in the skim portion of the milk. The bottle should be packed in an ice box, if the sample cannot be examined in an hour or two, or if it has to be forwarded to a distant place.

The examination is carried out to ascertain the number and nature of bacteria in milk. The milk within the udder of a healthy animal is ordinarily sterile, and possesses feeble germicidal properties, but it may easily be infected by a certain number of bacteria which may have gained entrance through the lactiferous ducts and teats. Hence fresh milk collected in the pail always yields 100 to 500 bacteria per c.c., but millions of bacteria are found in 1 c.c. of milk in India on account of the insanitary conditions of stables and the dirty methods by which the animals are milked. The pathogenic bacteria found in the milk are derived from—

1. The animal, *e.g.*, streptococci, staphylococci, tubercle bacilli, anthrax bacilli, foot-and-mouth disease germs and actinomyces.

2. The skin of the udder soiled with dry and wet dung, *e.g.*, several fæcal organisms.

3. The infectious material of human origin during the act of milking, storing or transit, *e.g.*, typhoid, diphtheria and cholera.

DISEASES CAUSED BY MILK (MILK-BORNE DISEASES).

Fermented or sour milk, if given to children, causes vomiting, flalulence and diarrhœa, and may also cause thrush or parasitic stomatitis, if it contains *Oidium albicans* besides the ordinary lactic acid bacillus. If it happens to contain purulent matter derived from abscesses or pustular eruptions on the udders of cattle, symptoms of severe gastric irritation may set in. Being also liable to absorb gases freely, it may become contaminated with offensive emanations and effluvia when kept in an open vessel and may thus cause diarrhœa.

The diseases, which are most commonly transmitted to man by contaminated milk, are tuberculosis, typhoid and paratyphoid fevers, cholera, diphtheria, scarlet fever, septic sore throat and foot-and-mouth disease. Malta fever is said to spread through the goat's milk infected with the *micrococcus melitensis*. Very often the epidemic outbreaks of these diseases have been traced to a particular source of milk-supply from the following characteristics :—

1. The onset of the outbreak is usually sudden, and it declines rapidly, if the milk-supply is stopped. This is generally not the case in an ordinary outbreak of epidemics.

2. The cases occur among those families, where the source of milk-supply is the same.

3. Those who take the largest quantity of milk in the family suffer most, as they absorb a larger amount of the poison.

4. Rich families suffer more than the poor, as the latter, as a rule, do not use milk.

5. The incubation period in such cases is generally shortened,

As lactiferous ducts form an important excretory channel, foreign matters of a vegetable nature taken along with the ordinary fodder may affect the quality of the milk or may impart merely a disagreeable odour, during the process of their elimination. For instance, admixture of euphorbeous plants will cause diarrhœa, and of *rhus toxicodendron* weakness, vomiting and diarrhœa. But ingestion of turnips and diseased potatoes along with the fodder merely gives a disagreeable odour without affecting the quality of the milk.

PRECAUTIONS AGAINST TRANSMISSION OF DISEASES THROUGH MILK.

1. Milk from a diseased cow, with sores on its udders or teats, must be condemned.

2. The udders and teats of the cow should be thoroughly washed before milking.

3. The hands of persons employed in milking should be washed and cleaned scrupulously. Clean clothes should be put on in order to obviate all chances of soiling the hands during milking.

4. Persons employed in milking or in its distribution should themselves be free from infectious diseases, and must not even be in attendance on others suffering from them.

5. Vessels and receptacles for milk should preferably be well tinned or be made of enamelled iron or aluminium and should be treated with steam or cleaned with boiling water before use. Vessels made of lead, copper and zinc, being liable to chemical action, should not be used. Besides, the vessels should have a tight-fitting cover to prevent infection and absorption of extraneous matters, and should never be kept open.

6. Milk-cattle should be housed in well ventilated stables provided with openings on opposite sides for efficient ventilation. The floors and walls of these stables should also be covered with impervious materials and provided with outlets for free drainage, and the feeding troughs should preferably

be made of stone. The animals should also be groomed properly at regular hours daily for some time, and taken out in the open fields to allow free grazing and exercise.

7. Boiling of milk is by far the safest method of treating it, as a high temperature obviates all risks of infection.

8. The sale of unhealthy and contaminated milk should be made penal by Acts of Municipal legislation, and licenses should be issued by the Municipalities authorising its sale for human consumption.

PREPARATIONS FROM MILK.

Cream.—If milk is allowed to stand for some time, its fatty constituents form a more or less dense layer on its surface commonly known as cream. These may also be separated quickly by means of a centrifugal machine. The amount of fat contained in home-made cream varies from 15 to 25 per cent. but generally varies from 30 to 50 per cent. in cream produced by a centrifuge. In addition to fat, protein, sugar and mineral salts are also contained in cream. It is yellowish-white in colour and is largely used for feeding children when casein disagrees with them. The remaining thin part of milk left after separation of cream is known as *skim-milk*, which is largely used as an article of diet for children and dyspeptics. To thicken it, a certain proportion of flour or other starchy material may be added. Commercial cream is adulterated with albumin, starch and sometimes other insoluble substances.

Cream may be preserved by sterilization or storage in a refrigerator. It is some times preserved by the addition of boric acid, hydrogen peroxide, sodium salicylate or sodium benzoate. The addition of preservative substances to cream is controlled in England by the Public Health Regulations, 1912 issued under the Public Health Act of 1907. According to the amended Public Health Regulations of 1917 boric acid may not be added to cream in excess of 0.4 per cent. and the product must be sold as preserved cream. The preserved

cream, whether containing boric acid or hydrogen peroxide should be labelled "not suitable for infants or invalids."

Junket.—This is an artificial preparation of milk prepared generally by adding rennet to it and allowing it to stand in a warm place until it curdles firmly. It is recommended for sick people either alone or sweetened with sugar.

Whey.—This is prepared by allowing milk to curdle by the addition of rennet or some weak acid while hot; whey is then slowly collected by straining the curdled milk through a fine piece of muslin. It is a highly nutritious form of fluid food containing as it does not only all the sugar and salts originally present in milk, but also a substantial proportion (1.24 per cent.) of proteins and fat. If added to an equal quantity of cow's milk, the composition of the result very nearly approaches that of human milk. As an article of diet it has been found useful in many ailments especially in enteric fever and diseases of the alimentary canal.

Butter-milk.—The part of the milk left after separation of butter is known as butter-milk. It contains more fat and proteins than whey. It contains about 8 per cent. of milk solids. Since casein is present in it in a very finely coagulated state, it has been found to be more easily digestible and beneficial in cases of gastro-enteritis.

Curd (Soured Milk).—In India this is commonly called *Dahi*. It is formed when fresh milk comes to be acted upon by lactic acid forming organisms, such as the lactic acid bacillus and the Bulgarian bacillus, which set up a process of fermentation and break up milk-sugar into lactic acid. It is made by adding some *matha* to boiled and cooled milk and keeping it for some hours. It has been found particularly useful in cases of diabetes and gout. It has also been highly recommended even as an ordinary article of diet on account of its efficacy in preventing the injurious decomposition in the alimentary canal which is attributed by Metchnikoff to the presence of the lactic acid bacillus.

Koumiss and Kefir.—These are forms of preserved milk containing a certain proportion of lactic and carbonic acids and alcohol. They are largely used in Russia and Tartary, and are prepared from mare's milk by a special process of fermentation. Of the two, koumiss may be prepared also from cow's milk, and being easily digestible and assimilable is largely used for dieting patients suffering from phthisis and other wasting diseases.

Mawa or Khoya.—As known in India, this is a form of desiccated milk prepared by a process of prolonged exposure of the milk contained in iron pans to a slow heat. It is largely used for preparing several varieties of Indian sweets. It should, however, be noted that even in this desiccated form it is liable to be infected by cholera vibrios and pus-forming micrococci, as the presence of all these has been demonstrated by Dr. Joshi's investigations.

Rabdi or Basundi.—This is still another Indian preparation of milk differing from Khoya, inasmuch as the milk is heated to such a degree as to give it only a thicker consistence rather than to completely desiccate it. As vendors expose it for sale in brass or bronze vessels known as *thalis*, it is very liable to be contaminated by disease germs. Ptomaines are also likely to develop when kept for long, giving rise to choleraic symptoms.

Butter.—This is prepared by churning the cream or curdled milk, when the fat globules contained in them tend to coalesce together and to entangle in their meshes some casein, serum and water. The average composition of butter is 12 to 15 per cent. of water, 1 to 3 per cent. of casein, 78 to 94 per cent. of fat and 0 to 7 per cent. of salt. It also contains fat soluble A vitamin. Butter fat contains 40 per cent. of olein which approximates very closely to the olein content of the human fat; hence its value as an article of diet. It is easily digested and is almost completely absorbed in the intestines. It is, therefore, very suitable to patients suffering from phthisis, diabetes and many forms of dyspepsia.

Good butter should neither be rancid, nor should it have an unpleasant odour. It becomes rancid owing to the splitting up of the glycerides and liberation of fatty acids, when kept for some time. It is also liable to decomposition, and when used in this condition, gives rise to symptoms of acid dyspepsia.

Common salt to an extent of two per cent. is ordinarily used as its preservative. Borax and boric acid are also used as preservatives.

Adulteration of Butter.—Water is the chief adulterant of butter. In a good sample of butter it should never exceed 16 per cent. Salt in excess, starch and boracic acid are sometimes added to butter, but the most important adulterant which is largely used in Europe and America is margarine. It is prepared by churning melted and clarified animal fats with skim-milk. Sometimes animal fats are substituted by vegetable fats, such as cotton, sesame and cocoanut oils. Margarine prepared from animal fats contains a small amount of fat-soluble A vitamin, and is a fairly good substitute for butter, which, owing to its cost is difficult to be used by the poor. Margarine prepared from vegetable oils does not contain fat-soluble A vitamin, and cannot, therefore, be considered a satisfactory substitute for butter. But the chief distinction between margarine and butter lies in the fact that the former contains only about half per cent. of volatile fatty acids soluble in water, and the latter contains nearly 8 per cent. Margarine is but little inferior to butter in its nutritive value, and is somewhat less digestible than butter.

Ghee.—This is clarified butter, and is largely used in India for preparing ordinary meals and various kinds of sweets. It is also used as such, being merely mixed with *dal*, rice and *chapatis*.

It is derived both from the milk of the cow and that of the buffalo. The process of its preparation consists in boiling and curdling the milk and in churning the latter diluted with a little water, when a large quantity of butter accumulates on

its surface, which on being boiled again yields the fatty constituents in the form of ghee.

The fluid left after its removal is known in India as *chhas or matha* which forms a refreshing beverage, rendered delicious with the addition of a little salt.

Good and genuine ghee should be clear, white or slightly yellowish in colour, and agreeable in smell and should not become stale within a few months. But being largely consumed as an article of food in India, it is frequently adulterated with injurious forms of fat, both animal and vegetable. The principal adulterants are margarine and ground-nut, cocoanut and cotton seed oils. Boiled potatoes and plantains are also added to increase the weight and thickness of its consistence. In short, the adulteration of ghee is practised on such an unprecedented scale that it is time that Municipal legislation were directed towards a stringent enactment of laws to penalise the offence and to offer an efficient protection to its wholesome trade.

An imported preparation which is nowadays sold in Indian *bazaars* as "vegetable ghee" is not ghee at all. It is a kind of margarine containing vegetable oils which have been solidified by exposure to nascent hydrogen. It contains no fat-soluble A vitamin, as it is completely destroyed during the process of solidification of oils. It is very inferior to ghee, and should not be called "vegetable ghee", so that the poor people may not be misled to purchase it as ghee.

Analysis of Ghee.—After careful investigations Drs. Dutt and Ghose of Calcutta have adopted the following standard for ghee :—

	Cow.	Buffalo.
Specific gravity ...	911 to 912	911 to 913
Soluble volatile acids in terms of deci-normal soda by Reichert Woolney method.	24 C.C.	30.5 C.C.
Melting point ...	34° to 35.5° C.	34° to 36° C.
Oleo-refractometer at 45° C. ...	—32 to 35	—32 to 35
Butyro-refractometer at 40.5° C. ...	41 to 42.5	41 to 43.5

The analysis chiefly consists in ascertaining fat contained in ghee, and in determining whether it is butter or animal fat or derived from vegetable oils. The following methods are adopted for this purpose :—

1. **Specific Gravity.**—This is usually taken by the Sprengel tube or the Westphal balance at a temperature of 100° F., this being the temperature at which there is the largest difference between butter fat and other animal fats. The specific gravity of pure butter fat varies between 911 and 913, and that of margarine from 901.5 to 906.

2. **Refractive Index.**—This is determined on a special instrument called a refractometer. At 35° C. it varies for butter from 44° to 49°, the average being 46°. Margarine gives about 54°, and cocoanut oil about 43°.

3. **Valenta Test.**—This depends on the intermiscibility of butter fat and strong acetic acid at a low temperature, whereas animal and vegetable fats mix at a much higher temperature. 3 c.c. of the ghee and 3 c.c. of glacial acetic acid (90 per cent.) are taken in a test tube. It is then immersed in hot water to heat the contents which are agitated all the while by a thermometer, and the temperature is noted when the ghee melts. For pure ghee the temperature should vary from 32° to 36° C., and for margarine the temperature is much higher, about 75° C. while an abnormally low Valenta figure indicates the presence of cocoanut oil.

4. **The Melting Point.**—To take the melting point of ghee it is melted over a water-bath at a temperature of 60° C., and filtered. A capillary glass tube is then immersed in the ghee, and when about three-quarters full is placed in ice to congeal the ghee inside the tube. It is then fixed to the bulb of a thermometer, and both are dipped in water contained in a beaker with a little ice in it. The beaker is placed in another with water, and the whole is heated slowly over a flame, until the congealed ghee melts and rises. The temperature is then noted and recorded as the melting point. This varies in the case of pure ghee from 34° to 36° C. It is much higher in the case of animal fats, while lower in the case of vegetable fats.

5. **Wellman's Colour Test.**—This is a useful test for determining the presence of vegetable fats. One gramme of ghee is dissolved in 5 c.c. of chloroform in a test tube to which are added 2 c c. of phosphomolybdic acid and a few drops of nitric acid. The contents are thoroughly mixed by shaking the tube. On allowing it to stand for some time a green colouration appears in the upper layer, if the vegetable fats are present in the ghee.

Cheese.—This is another preparation of milk consisting of coagulated casein and a variable proportion of fat, lactose

and salts. It is prepared by adding rennet to pure milk. It may also be manufactured from skimmed milk or a mixture of whole and skimmed milk. Good cheese usually contains twice as much nitrogen and three times as much fat as the same weight of meat. On an average cheese contains 33.9 per cent. of water, 4.2 per cent. of ash, 30 per cent. of fat, 4.3 per cent. of nitrogen and 27.3 per cent. of casein. It is a nutritious article of diet, and may form a substitute for proteins contained in a meat dietary. It is, however, difficult to digest by delicate stomachs unless thoroughly masticated. When cheese is kept for some months, it undergoes a process of decomposition, known as "ripening", owing to the action of enzyme and micro-organisms. By this process the casein undergoes a fatty change and aromatic acids are produced, which give the characteristic flavour to the cheese. A special form of ptomaine known as *tyrotoxicon* is said to be elaborated during its fermentation, which causes vertigo, dryness of the mouth, nausea, vomiting, diarrhœa and collapse with cramps in the muscles.

VEGETABLE FOODS.

These contain a lesser amount of proteins than animal foods, but contain a larger proportion of fats and carbohydrates. In addition, they contain a considerable amount of water and salts. The mineral salts consist chiefly of chlorides, carbonates and sulphates of sodium, potassium, magnesium, calcium, iron and silicon. Vegetable foods are not mostly digested in the stomach on account of the presence of starch which forms their chief ingredient, and which is not affected by the gastric juice. They are, therefore, mainly digested and absorbed in the intestine.

Vegetable foods are commonly grouped under the following heads :—

1. Cereals.
2. Pulses.
3. Roots and tubers.
4. Green vegetables.
5. Fruits.
6. Nuts.
7. Fungi.

Cereals.—These are wheat, barley, millet, maize, rice, rye and oats. They are all seeds of plants belonging to the natural order "graminacæ." These contain about 70 per cent. of starch and a proportion of proteins varying from 6 to 18 per cent. Besides, they also contain a small and varying amount of vegetable fat and salts.

Wheat.—This is largely used as staple food in many parts of India, except in Southern India where its place is taken by rice. Ordinarily two varieties of it are met with in India, *viz.*, the white and the red. The grain of wheat consists of three parts, *viz.*, (1) an outer tough or branny layer called pericarp forming $13\frac{1}{2}$ to 15 % of the grain and composed chiefly of cellulose and mineral matter, (2) a middle layer called endosperm or kernel consisting chiefly of gluten and starch cells and forming 80 to 85 per cent. of the grain, and (3) a germ or embryo constituting $1\frac{1}{2}$ to 2 % of the grain and lying at its broad end. During the process of milling its component parts are broken up, and ground into flour (*atta*), the by-products being *sooji* and *maida*. The bran which is separated from flour by sifting it through a sieve is ordinarily rejected, but may be used advantageously with *atta* (flour) by persons suffering from chronic constipation. The wheat grain is also crushed into small coarse pieces under a mill, and by the addition of water or milk is cooked into a sort of porridge, which forms a nutritious article of diet.

The chief nitrogenous substance present in wheat-flour is gluten, which may be obtained as such by adding water to flour and straining it through fine muslin. Besides 8 to 12 per cent. of gluten, it contains about 15 per cent. of water, 60 to 70 per cent. of starch and a little sugar and dextrine. From its composition it is thus evident that it is poorer in salts and fat, necessitating the admixture of both when used as an article of food.

A good quality of wheat-flour should be white or yellowish in colour, and must neither have a musty odour nor

feel gritty when rubbed between the fingers. Old and bad flour, on the contrary, has a dark brown or deep yellow colour. Flour becomes unwholesome by storage in a damp place owing to the growth of moulds and fungi, and is apt to produce dyspepsia and diarrhœa.

Wheat-flour is ordinarily consumed by the people of India in the form of thin cakes known as *chapatis*. They are eaten quite fresh, since, if stale, they become rough, hard and difficult to digest. The by-products known as *sooji* and *maida* enter largely into the composition of several kinds of Indian sweets, which are, however, more difficult to digest than those prepared entirely from milk.

Bread ordinarily known as *double roti* in India is also used by certain classes of people, especially Europeans and the domiciled community of Anglo-Indians, and is prepared by adding yeast to the flour prior to baking with a view to give it a spongy consistence through the production of a large amount of carbonic acid gas, which is a product of fermentation of its starchy elements. If added in excess the unaltered yeast left in the bread gives rise to symptoms of acid dyspepsia. To prevent, therefore, the unpleasant symptoms arising out of incomplete fermentation, bread may be prepared by adding baking powders containing sodium carbonate and tartaric or citric acid, or by forcing through the dough freshly prepared carbon dioxide gas under pressure. Alum, though it causes constipation and flatulent dyspepsia, is largely used to impart a fine white colour to bread and as a preservative against such injurious fermentation as makes it sour and unfit for consumption.

Biscuits are small well-baked cakes made out of a simple mixture of flour and water, but sometimes to improve their nutritive qualities or to make them more palatable, egg albumin, butter, milk and sugar are also added. They are said to be more nutritious than bread on account of their containing a larger amount of protein and carbohydrates bulk for

bulk; besides, they keep well for long on account of their containing a very small proportion of water. On account of their condensed form they are more easily portable, and their provision is, therefore, largely requisitioned in campaigns and war.

Barley.—This is grown on a large scale both in temperate and tropical climates. It is known as *jau* in India, and contains less protein, but more fat and mineral salts than wheat. The whole grain when ground constitutes barley meal, and is largely used as horse-food. The grain left after the removal of its husk is sold as Scotch or pot barley. This, when rounded and polished, is sold as pearl barley. Pearl barley ground into flour is known as patent barley. Barley water is prepared from pearl barley, and is used as a demulcent beverage for the sick and infants.

Barley is unsuitable for making bread or *chapatis* owing to very little gluten contained in it; hence it is mixed with wheat or gram flour before it is made into *chapatis*.

Malt is formed when barely is moistened and allowed to germinate, the germination being stopped at a certain point by exposure to dry heat.

Millets.—Millets are largely grown in India, and used as food chiefly by the poor people. The chief varieties are *joar* and *bajra*. From a dietetic point of view they are less nutritious than wheat.

Maize or Indian Corn.—This is commonly known as *maccai* or *bhutta*. Chemically it contains 9 to 12 parts of proteins, 65 parts of carbohydrates, 5 to 8 parts of fat, 1 to 2 parts of mineral salts and 14 parts of water. It is, therefore, a very nutritious article of diet, yielding energy equivalent to about 1,800 Calories per pound. This high Caloric value is due in part to the high percentage of fat. But, owing to this large amount of fat it is apt to become rancid or mouldy. The flour of maize being deficient in gluten cannot be taken in the form of *chapatis*, but is ordinarily consumed in the

form of porridge. The flour has also a peculiar harsh flavour, which may be removed by the addition of a dilute solution of caustic soda. The flour thus removed of its flavour is sold as Corn flour.

The protein of maize flour is deficient in amino-acids essential for transformation into body tissues and also in fat-soluble A vitamin, hence it is supposed to cause pellagra when the diet chiefly consists of maize.

The green seeds of maize furnish an excellent food product during the milky stage and during the growing season. These are sweet and tender, and delicious, and are usually eaten after their green ears are roasted in fire.

The dried seeds are commonly eaten by the poor after treating them with hot sand as is ordinarily done by " bharbhunjas ".

Rice.—This is another staple food of Indians in many parts of the country, especially Bengal and Southern India. It is prepared from paddy (*dhan*) by removing the brown husk by means of a large wooden mortar and pestle, or by means of a hulling machine. In some places paddy is first soaked in cold water for 24 hours, and then dried by exposure to the air, before it is removed of its husk. Rice thus prepared is known as *átáp* or sun-dried, and is generally eaten by orthodox Brahmans and widows. The enzymes of the grain are not destroyed by this method. Rice is known as *balam*, when the husk is removed after the paddy is sprinkled with hot water. The water inflates the grain, and when dry facilitates the removal of the husk. The heat is not sufficient to destroy the enzymes or coagulate the proteids, but avoids the number of hours that are required to swell the grain by simple steeping in cold water. Sometimes paddy is soaked in large and open vessels, boiled for a few minutes, and then dried in the sun before the husk is removed. This process destroys most of the enzymes, and coagulates the surface proteids in the grain. This rice is called *siddha* or parboiled rice.

Rice contains 78.3 per cent. of carbohydrates but a very small proportion of protein (7.3%). It is also deficient in salts, and to make up these deficiencies it is taken along with other articles of food that are richer in proteins and salts.

Rice is easy of digestion, and is absorbed with very great completeness in the intestine, leaving a very small residue due to the small amount of cellulose. It has been estimated that 2½ ounces of cooked rice leave the stomach in 3½ hours, and enter the intestine, where the digestion is completed. The usual practice of boiling rice in a very large quantity of water and of subsequently draining away the excess of fluid deprives it of much of its nutritive value, inasmuch as the salts in solution are also got rid of along with it. It is, therefore, desirable that rice should be cooked by steaming or should be boiled in as much water as it will absorb.

Stored up rice of some standing is more easily digestible than that derived from a fresh harvest; the latter, when consumed, gives rise to symptoms of indigestion and diarrhœa. As in the case of wheat the storage of rice in damp places is also injurious, seeing that excess of humidity sets up decomposition and makes it unfit for consumption. Hence rice should always be stored in dry, cool and ventilated places.

Rice deprived of its entire pericarp and germ, which contain the antineuritic or water soluble B vitamin, is known as highly milled or polished rice. The exclusive use of such rice as an article of diet is said to give rise to a deficiency disease, called beri-beri or epidemic dropsy. But Megaw[1] suggests that beri-beri is caused by the action of some low form of vegetable organism on polished rice that has been stored in a hot and damp place, while Acton and Chopra[2] have proved from their experimental investigations that beri-beri and epidemic dropsy are different clinical aspects of a

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1. Ind. Med. Gaz., May, 1921, p. 181.

2. Ibid., Jan., 1925, p. 1; Mar., 1926, Indian Medical Year Supplement, p. 12.

toxic syndrome caused by the ingestion of certain poisonous pressor bases formed in husked, parboiled and stored rice under certain conditions of temperature and humidity. These poisons are possibly produced by a spore-forming bacillus of the B. vulgatus, which attacks the rice, particularly during the hot, humid months of the monsoon, and especially when the rice is stored in unventilated rooms and godowns. The bacillus is found inside the diseased gram of rice. The enzymes and vitamins of rice prevent the attack and the growth of these poisonous bacteria, hence parboiled and polished rice is especially liable to invasion of these bacteria.

Megaw suggests the following chief measures for the prevention of beri-beri[1] :—

1. The only kind of rice which should be eaten is fresh parboiled rice, such as is manufactured in Calcutta and such as is used by the villagers in Bengal.

2. Special attention should be paid to the storage of rice ; the rice should be stored—

(*a*) For the shortest practicable time.

(*b*) In dry, cool and ventilated places, which should be thoroughly cleansed out after the old stock has been used up. It is dangerous to go on adding fresh supplies of rice to a stock of old rice.

(*c*) When rice has to be kept for any length of time, it should be stored in the form of paddy, not as manufactured rice. Even paddy should be very carefully stored to prevent possible changes of a harmful nature from taking place.

(*d*) If beri-beri appears, the supply of rice which has been in use previously by those who are attacked should be regarded as unfit for use, and the store-houses or receptacles in which this rice has been kept should be regarded as infected and as likely to contaminate any further supplies of rice which may be placed in them.

1. Ind. Med. Gaz., May, 1923, p. 202.

Other articles of food should also be stored under good conditions, apart altogether from the possibility of their being concerned in causing beri-beri.

3. Adulteration of wheat flour should be looked for and if detected should be severely penalised.

4. When beri-beri breaks out, the victims and the other people in the locality should, if possible, stop eating rice; they should live on a diet rich in fresh available proteins and in all the essentials of an ideal diet including vitamin B.

Rye.—The black bread used in Germany is derived from rye. It is very nutritious, as it contains about 10 per cent. of proteins and 2 per cent. of fat, but it is very acid and unpalatable and apt to produce diarrhœa. Rye is also liable to be attacked by a fungus, known as ergot of rye, the prolonged use of which may give rise to the symptoms of ergotism, *viz.*, painful cramps in the limbs. and gangrene of the extremities.

Oats.—These are commonly known as *jai* in India. They contain a large amount of proteins, fat and mineral salts, especially phosphates, and are, therefore, highly nutritious. When the husk is removed. the oat grain is known as *groats or grits*, which when ground into fine flour is called oatmeal.

Oatmeal is used in the form of gruel or porridge as it cannot be made into bread or *chapatis* owing to the lack of gluten. Owing to the large amount of cellulose it acts as a laxative, but sometimes sets up diarrhœa by unduly stimulating the intestine. It should not be given to persons suffering from gout, as it contains appreciable quantities of purin bodies (uric acid formers).

Pulses.—These are the seeds derived from the plants belonging to the natural order "leguminosæ." Those that are chiefly used in India are *arhar* (*tuwr*), *moong*, *chana* (gram), *mattar* (peas), and *seims* (beans). These legumes contain a greater amount of proteins, vegetable fats and salts than the cereals. The protein present in them is legumin or vegetable casein varying from 17 to 35 per cent. This albumin generally

contains in combination sulphur and phosphorus, which, while adding to its nutritive value, render it somewhat difficult of digestion, and are therefore likely to produce flatulence on account of albumin breaking up during the process of digestion into a large quantity of sulphuretted hydrogen. The salts contained in them are chiefly those of potassium and calcium. Pulses also contain quantities of purin bodies; hence they should not be allowed to persons suffering from gout or rheumatism.

Pulses are eaten fresh as well as dry. Fresh seeds become soft and succulent by cooking, and so are easy to digest, but the dried ones are apt to lead to indigestion owing to a large amount of thickened and indigestible cellulose. It is supposed that the dried pulses are deprived of the antiscorbutic vitamin contained in them, but if they are soaked in warm water, and allowed to germinate, the vitamin reappears in 24 to 48 hours. Hence the practice of eating germinated pulses (*ghoogni*) among Hindus is most scientific from a health point of view. The following is a method[1] for germinating dried pulses to reconstitute the antiscorbutic vitamin :—

The whole seeds should be soaked in water for 24 hours, when 100 per cent. water is absorbed and the germinating process commences. At this stage the antiscorbutic vitamin has made its appearance. But the amount produced is greatly increased if the germination is continued for a day or two more. For this purpose the excess of water is poured off and the seeds are allowed to remain damp, with access of air. In warm climates it is enough to soak the seeds for 12 hours and one day or less for further germination. The germinated pulses are soft and palatable to eat, but should not be boiled for a long time lest the antiscorbutic principle may be destroyed by high temperature.

As pulses are largely used by the majority of vegetarian Indians in the form of *dal*, they are thoroughly decorticated prior to cooking, to render them more digestible. They are

1. Medical History of the Great War, Vol. II, p. 97.

also used after being finely ground as flour, which latter enters largely in the composition of some forms of sweets and vegetable cakes.

These pulses are also liable to undergo decomposition if stored in an undried state or in a damp place. The use of decomposed pulses should be condemned as it is liable to cause vomiting and purging. *Masoor* or *kesari* (*Lathirus sativus*) when largely eaten is apt to give rise to a train of symptoms simulating that of spastic paraplegia ordinarily described as *lathyrism*. From his experiments Acton[1] suggests that these symptoms are due to a toxin of the nature of a water soluble amine present in the seeds of *Kesari*. But Anderson, Howard and Simonsen[2] have carried out investigations and are of opinion that *Kesari dal* is itself harmless and that the danger of the disease lies in its contamination with *akta*, a leguminous weed called *Vicia sativa*. In this connection it may be mentioned that Acton and Chopra have now been able to confirm their work by carrying out further investigations.[3]

The obvious remedy for the prevention of lathyrism is, therefore, to grow *Kesari* in pure culture by removing *akta* in the early stages so that when the crop flowers, it is practically pure.

Roots and Tubers.—These contain chiefly starch and sugar with a large amount of water, but very little of nitrogenous matter. As an article of food they are, therefore, less nutritive than both cereals and pulses. The mineral salts contained in them are chiefly potassium salts, but these are liable to be dissolved when cooked in water. Hence they should either be cooked by means of steam or the water in which they are cooked should be utilized. Digestibility of these roots and

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1. Ind. Med. Gaz., July, 1922, p. 241.
2. Ind. Jour. of Med. Research, April, 1925, p. 613.
3. Causation of Lathyrism by Vicia sativa, Abstract of Papers, Far Eastern Association of Tropical Medicine, 1927, p. 104.

tubers depends largely upon the quantity of cellulose present in each, but they are only indifferently absorbed, and are apt to cause digestive disturbances owing to their bulk, if eaten in large quantities. Their chief examples are potatoes, turnips, beetroots, carrots, onions, radishes, sago and arrowroot.

Potato is the most important member of this group. When properly cooked it is easily digestible. In order not to allow its salts to pass into water it should be boiled without peeling off the skin, or should be steamed or roasted in its skin. Potatoes possess the antiscorbutic vitamin. They undergo fermentation very readily ; hence they should not be allowed in certain diseases, such as dilatation of the stomach.

Carrots contain about 10 per cent. of cane or fruit sugar, and are, therefore, more nutritious than turnips.

Onions have a very characteristic odour due to the presence of allyl sulphide, an organic compound of sulphur. This is supposed to stimulate the flow of gastric juice, and to act as a mild laxative. Onions contain very little starch and sugar, and can, therefore, be taken by persons suffering from diabetes. They possess the antiscorbutic vitamin.

Sago and arrowroot, when cooked with milk and sugar, make an easily digestible food for sick people.

Green Vegetables.—Green vegetables are largely used in India. They contain about 90 per cent. of water, 2 per cent. of nitrogenous substances, about 4 per cent. of starch, about ½ per cent. of fat and a large quantity of alkaline salts combined with organic acids. They should always be made to contribute largely to a mixed or a purely vegetable dietary, as they supply organic acids, mineral salts, and increase the palatibility to the dietary. They may be cooked by boiling, frying and roasting or baking. Fresh green vegetables are rich in the antiscorbutic vitamin. The principal ones possessing this vitamin and in common use are brinjal, lettuce, salads, tomatoes, cauliflower and cabbage. Most of these vegetables are grown on soils treated with sewage or sullage water and

are, therefore, liable to cause cholera, enteric fever and dysentery, or are apt to convey round worms, ankylostoma, etc., unless they are thoroughly cooked and boiled.

Green vegetables are also beneficial to persons suffering from habitual constipation, since a large quantity of cellulose contained in them is likely to aid in stimulating the intestinal peristalsis.

Fruits.—These contain a large amount of sugar, vegetable acids and salts besides water. They derive their pleasant taste from the constituent vegetable acids. Their prohibitive cost is, however, a bar to common use. Some of them, specially lemon, mango, papaya and tamarind, possess highly antiscorbutic properties. They should ordinarily be eaten when fresh and ripe after they are washed, as they are likely to be contaminated with dirt and other infectious material by the fruit-pickers, as well as by the vendors. Ripe fruits are also laxatives and owing to the conversion of acids into carbonates render the urine alkaline, and increase the total excretion of salts and other materials by stimulating the kidneys and indirectly the skin. The use of unripe or over-ripe fruits is harmful, as it is likely to produce diarrhœa and dysentery, and thus to predispose to choleraic attacks.

Nuts.—Nuts are highly nutritious, as they contain, on an average, 15 to 20 per cent. of protein, 50 to 60 per cent. of fat, 9 to 12 per cent. of carbohydrate, 3 to 5 per cent. of cellulose, 1 per cent. of mineral matter and 4 to 5 per cent. of water. Owing to such a high percentage of proteins and fat they have practically the same nutritive value as meat, and are largely recommended for the use of diabetic patients, as they contain a small amount of carbohydrates. The greater portion of the cellulose contained in the nuts leaves the body unchanged ; hence it is necessary that the nuts should be very thoroughly masticated so that their nutritious portion may be readily acted upon by the digestive secretions. Nuts are likely to become rancid in a few months, when their nutritive value and palatibility are

diminished. The chief examples of nuts are cocoanuts, almonds, walnuts and dry dates.

Fungi.—These have got very little nutritive value, and are difficult to digest, owing to the large percentage of cellulose, but possess an excellent flavour. The chief varieties of edible fungi are the mushroom, truffle and morel. All fungi should, however, be avoided when overripe or attacked by slugs. Those that soften readily are usually dangerous. Fungi generally absorb poisons from the medium on which they are growing. Hence fungi growing in or near dunghills should not, as a rule, be consumed.

Food Auxiliaries.—These include sugar, honey, salt, condiments and beverages which, though not nutritious themselves, are largely used for imparting a delicious aroma to articles of food and for rendering them generally palatable. They also help digestion by stimulating the healthy secretion of the gastric juice. Sugar, honey and salt are strictly speaking not included in food auxiliaries, but may conveniently be described here.

Sugar.—This is derived from the sugarcane, sugarbeet, sugar-maple, etc. Only a small portion of it is absorbed in the stomach, but the remainder is absorbed in the intestines without leaving a residue. Taken in excess it gives rise to acid fermentation and irritates the intestinal canal. It is a source of much energy and muscular power. The use of sugar lessens fatigue. Hence the custom among Indian labourers and cultivators of eating *goor* (treacle) with their *chabena* (parched gram and rice). It is the basis of all sweetmeats, and is the preservative agent in jams.

Honey.—This is commonly used by Indians in winter. It consists of the saccharine substance collected by bees from the nectaries of flowers, and deposited in the cells of the honeycomb. Honey contains dextrose and lævulose. An ounce of honey yields energy equal to 95 Calories. It contains formic acid, which prevents fermentation, and its accompanying symptoms, flatulence and toxæmia.

Honey is largely adulterated with glucose, starch paste and cane sugar, and imitated by the itinerant vendors by adding a piece of genuine honeycomb to a vessel containing glucose syrup. Under the microscope genuine honey shows the presence of pollen grains.

Salt.—About ten grammes of common salt or sodium chloride should be used per day with the food rations, as most of the food stuffs are deficient in it. Vegetarians need salt more than meat-eaters. Owing to its taste it is not possible for any one to take it in excess but, if any one did, it would cause diarrhœa.

Condiments.—Condiments chiefly contain aromatic oils and are therefore excellent antiseptics and have a soothing effect on an irritable stomach and intestines. They expel flatus, and relieve the griping pain caused by many vegetable foods.

The condiments that are chiefly used in India are chillies (*lal mirch*), coriander (*dhania*), cummin (*zira*), turmeric (*haldi*), cinnamon (*dalchini*), black pepper (*kali mirch*), mustard (*rai*), saffron (*zafran*), dill (*suwa*), cloves (*lavang*), nutmeg (*jayfal*), cardamom (*ilaichi*), fenugreek (*methi*), pimento (*tamalpatra*), and mace (*javitri*). Vinegar, chutnies and pickles of limes, mangoes and bael fruits are also used.

Beverages.—Those in ordinary use may be divided into three groups, *viz.*, (*a*) mineral waters, (*b*) infusions of tea, coffee and cocoa, and (*c*) alcohols or fermented liquors.

(*a*) **Mineral Waters.**—Mineral waters are either natural or artificial. Natural are those derived from springs and which contain salts of potassium, sodium, lithium and magnesium or merely gases, for instance, carbonic acid gas (CO_2) in solution. The artificial forms which are known as ærated waters are usually prepared by subjecting water containing different salts in solution to a process of gaseous saturation. Both forms of mineral waters are in common use. It is said that cholera bacilli are unable to contaminate waters

saturated with carbon dioxide gas, and thus their use in the form of soda-water has been particularly recommended in places where the disease may be prevalent and the source of water-supply be doubtful. Soda-water is also largely used for diluting a purely milk dietary of invalids. Boiled or distilled water should invariably be used in manufacturing ærated waters to avoid all chances of contamination and infection.

(*b*) **Tea.**—This consists of the dried leaves of *Camellia thea* grown in China, India, Ceylon and Japan. In contains principally an alkaloid thein, besides a varying proportion of tannin and other extractives. An infusion prepared from the leaves (2 teaspoonfuls to a pint of boiling water for 5 minutes) is ordinarily used, while a decoction has been found injurious on account of its containing a very large proportion of tannin. Tea helps to digest milk, and should be used by those who cannot digest milk by itself. It is, however, advisable not to take a very large quantity of tea along with the principal meals, as the tannin contained in it is liable to coagulate their albuminous ingredients and thus to render them difficult of digestion. If taken in moderate quantities it acts as a mild stimulant and restorative ; but when taken in excess, it causes constipation, indigestion, nervous depression, insomnia and gives rise generally to a state of neurasthenia.

Coffee.—This is obtained from the seeds or berries of the *Caffea arabica* grown in Arabia, Abyssinia, Southern India and other tropical countries. It contains an alkaloid caffein, (about 1%), together with a certain amount of fat, nitrogenous substances, sugar and mineral salts. It is ordinarily used in the form of powder, the seeds having previously been roasted and ground. An aromatic oil, called caffeol, is produced when the coffee seeds are roasted. It imparts a characteristic flavour and aroma to the coffee. This fragrance is rapidly destroyed by keeping ; hence it is desirable to use freshly roasted coffee. A decoction prepared from it is ordinarily used mixed with a little sugar and milk, but an infusion

prepared with nearly boiling water is to be preferred, as the fragrance is not destroyed. Two ounces of coffee are necessary to make a pint. The third method of preparing coffee is by percolation, in which boiling water is poured over and allowed to percolate through finely ground coffee. In this process 11 to 15 per cent. of coffee is dissolved, while in the other two processes about 20 per cent. is dissolved. Coffee is said to be an efficient restorative, and is thus known to dissipate symptoms of brain fag. It stimulates the nervous system and removes the sensation of fatigue. It causes wakefulness and increased brain action.

Its chief adulterant is chicory, the root of which is dried, powdered and mixed with coffee powder.

Cocoa.—This is derived from the seeds or beans of *Theobroma cacao* growing adundantly in the West Indies. These beans contain an alkaloid, theobromine, together with a certain amount of fat, starch and salts. As a beverage it is preferred by some persons to tea and coffee on account of its being more palatable and less astringent in its action. It is also nutritious, and much more sustaining than tea or coffee. A breakfast cupful of the beverage prepared with $\frac{1}{3}$ ounce of cocoa yields about 40 Calories of energy.

The adulterants of cocoa are ground-nut seeds, sesame seeds, cotton seeds, potassium carbonate, iron oxide, starch and sugar.

Chocolate is a preparation consisting of ground cocoa from which a large portion of the fat has been removed, and is mixed with sugar, starch and flavourings.

(*c*) **Alcohols or Fermented Liquors.**—These are divided into three classes, *viz.*, spirits, wines and beers according to the amount of alcohol contained in them. The forms of spirits in ordinary use are brandy, rum, whisky and gin. The percentage of alcohol in them is about 40. Those belonging to the class of wines may be divided into light and strong according to the percentage of alcohol contained in them. To

the former belong the Bordeaux, Burgundy, Rhine wine, Champagnes and Moselles, all of which contain less than 15 per cent. of alcohol; while under the latter are included Port, Sherry and Madeira in which the percentage of alcohol is higher and ranges from 15 to 25. All these wines are derived from grape juice by a process of fermentation. Beers are derived from malt, hops and barley, and contain from 4 to 5 per cent. of alcohol.

The indigenous forms of liquor ordinarily used by poor Indians are those derived from fermentation of rice and *mahua* (known as arac), and toddy (*tadi*) derived from fermentation of palm or date juice.

Alcohol in some form or other has from the very earliest time been used as an exhilarant by the human race in every part of the globe. Even the ancient vegetarian Hindus used it in the form of "somarasa," a fermented juice prepared from the plant "Soma." If taken in small doses it is said to promote digestion by increasing the secretion of the gastric juice. Taken in such small quantities or within a moderate limit of an ounce or two it may even form an article of food, when it is desirable to minimise oxidation in the process of food metabolism; but its use in case of fever on account of its hypothetical antipyretic virtues is erroneous, while its consumption in large quantities as a preventive against the injurious effects of cold is positively mischievous as it is well known that its perniciously excessive use in temperate and cold climates strongly predisposes persons to fatal respiratory affections of a catarrhal type, for instance, pneumonia. Even under ordinary climatic conditions, when taken in excess, alcohol is apt to delay digestion, to cause intestinal catarrh and eventually to lead first to congestive and then to cirrhotic conditions of the liver and kidneys, accompanied by hydræmic conditions of the body cavities (dropsy) and tissues generally (anasarca); thus verifying a well-known Spanish saying to the effect that "Those who drink wine die in water."

CHAPTER XIII.

THE DISPOSAL OF REFUSE.

THE refuse of a town may well be described under the following headings :—

1. The dry refuse of a house, such as ashes, dust and crumbs of food.

2. Washings from the house, particularly those of the kitchen, lavatory and bath-room.

3. The sewage refuse consisting of human excreta.

4. Refuse from stables and cowsheds containing the animal excreta.

5. Refuses from slaughter-houses.

6. Market refuse.

7. Refuses and waste water from factories.

8. Street sweepings.

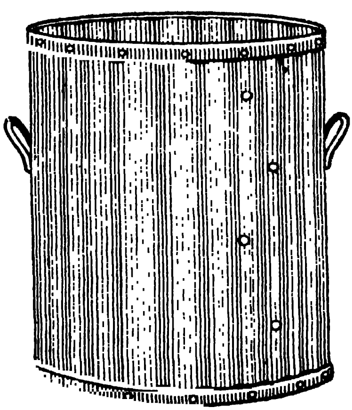

Fig. 20—Dust-bin of corrugated iron.

(From The Empire Engineering Company, Cawnpore.)

To ensure an efficient sanitary condition of a town the disposal of all these forms of refuse should be properly arranged for.

All forms of dry refuse derived from houses, stables, markets, slaughter-houses, factories and the streets should first be collected in receptacles ordinarily known as dust-bins. These dust-bins should be placed at convenient places in the streets and busy parts of a town on a slightly raised and paved platform. The platform should be in a position as far from the dwelling houses as possible, and sheltered from winds and sun. It should be protected from rain by a roof over it. A drain should lead away any liquid collecting on the platform. The dust-bins are either fixed on the platform, or are moveable and fit into a groove made thereon. The fixed ones which are generally known as ash-pits, are square in shape, and made of bricks plastered on the inside with cement. These are difficult to clean. The moveable are circular, made of corrugated iron and open at both ends. To facilitate the removal of refuse the small dust-bins provided with a pair of handles are better than large and unwieldy ones. They should be cleared at least once a day. One dust-bin is sufficient for a population of 1,000 inhabitants. If possible, small, covered dust-bins should be kept near the doors of private houses or in the compounds of private bungalows.

The collections of refuse in these receptacles are eventually disposed of in either of three ways, *viz.*, incineration, dumping or sorting.

1. **Incineration.**—Incineration of refuse in destructors or incinerators has been largely adopted by most of the municipalities in India, as it is the safest and most hygienic method of getting rid of refuse. The incinerator consists of one or more furnaces, which require coal to start the burning of refuse, but, after a time the heat generated is so much as to consume the whole of the refuse. To prevent nuisance, the escaping foul-smelling smoke may

be led into the furnace and burned. During the process of burning the temperature may be raised as high as 2,000° F., by means of a forced draught, and the heat generated may be used for producing steam, which can be utilised for public purposes, *e.g.*, lighting or driving a mill. The chief advantages of incinerating the refuse are that the cost of carting it is minimised to a very large extent, it is reduced to almost one-third of its volume, and the residual ash or clinker can be used for making roads, mortar, cement or filter beds. The only disadvantage is that the incinerators will not burn in the rains.

At some places the night-soil is mixed with the refuse, when nuisance generally arises, inasmuch as the menial staff are found, as a rule, careless in the matter of mixing up a due proportion of combustible material, such as wood shavings, saw dust, coal dust, and damaged *bhoosa*. There is, however, very little nuisance, if the process is thoroughly supervised, or if a high temperature incinerator is used. In such an incinerator condemned carcasses and waste materials resulting from offensive trades can also be consumed.

The simplest type of an incinerator is that in which there is a furnace with a chimney to let out smoke. One recommended by Dr. MacDonald, Health Officer of Madras, at the second All-India Sanitary Conference consists of a brick masonry with three rows of iron bars superimposed and each row placed at right angles to the other in the bottom of the furnace. Ample provision is made for the draught by making apertures in the bottom. Above the furnace is an upright masonry chimney on which an iron chimney, 12 to 16 feet long is usually placed. An iron lid with a baffle plate is placed over the furnace, which is opened or closed by means of a wire pulley attached high up on one side of the masonry chimney.

Several types of closed incinerators have been in use, but the essential feature of all these is the possession of a baffle

plate, so placed that all fumes are driven through the hottest part of the incinerator, or combustion chamber, before passing up the chimney. The chief varieties that are the best and most useful are the Sialkote improved-type incinerator, Meldrum destructor, Harrington's improved refuse incinerator and the Horsefall incinerator.

Fig. 21—Incinerator.

The Sialkote incinerator is quite economical. One having a four feet diameter is capable of consuming about 400 cubic feet of refuse per day.

The Meldrum destructor is manufactured by Messrs. Meldrum Brothers of Manchester, and depends for its action upon a forced draught produced by a steam jet. The fumes are burnt by passing through a combustion chamber, which separates the furnace from the flue. It is claimed that all the noxious material is decomposed by very high temperature into harmless and inoffensive gases. The furnace is ordinarily fed by hand, but may be fed through a hopper arranged at one end. This incinerator was used with great success during the last Great War. A small variety of this type was capable of dealing with the refuse and excreta of 6,000 men, while a bigger variety dealt with the excreta of 7,500 to 8,000 men.

Harrington's incinerator has been in use in India for several years. Each furnace is capable of burning 500 to 1,500 cubic feet of refuse in a day, and is managed by one man only. The furnace is charged at the top, and the ashes removed from below the fire bars.

The Horsefall incinerator is used in Colombo. It consists of 6 large cells and combustion chambers, each cell burning 10 tons in 24 hours.

2. **Dumping.**—In this method the receptacles are emptied into refuse carts fitted with covers, which are taken out of the town. These are ordinarily driven by bullocks or buffaloes, but in large cities, such as Bombay, Calcutta, Lucknow, etc., the refuse is carried in motor trucks. In small and narrow lanes and by-lanes where refuse carts cannot go, wheel-barrows worked by hands are generally used.

The refuse is then dumped into pits or hollows to fill them up. Sometimes it is dumped to fill up low-lying lands in the town itself. When thus filled up, the ground is called "made soil," which should not be selected for building a house for at least 20 years. This method of disposal is, however, not an ideal one, as the accumulations of refuse are liable to pollute the neighbouring water-supply, to breed rats and flies and to be disturbed frequently by dirt-seeking animals like pigs, and

thus to give off offensive effluvia. Hence the dumping ground should be far away from habitations, and not near any well·

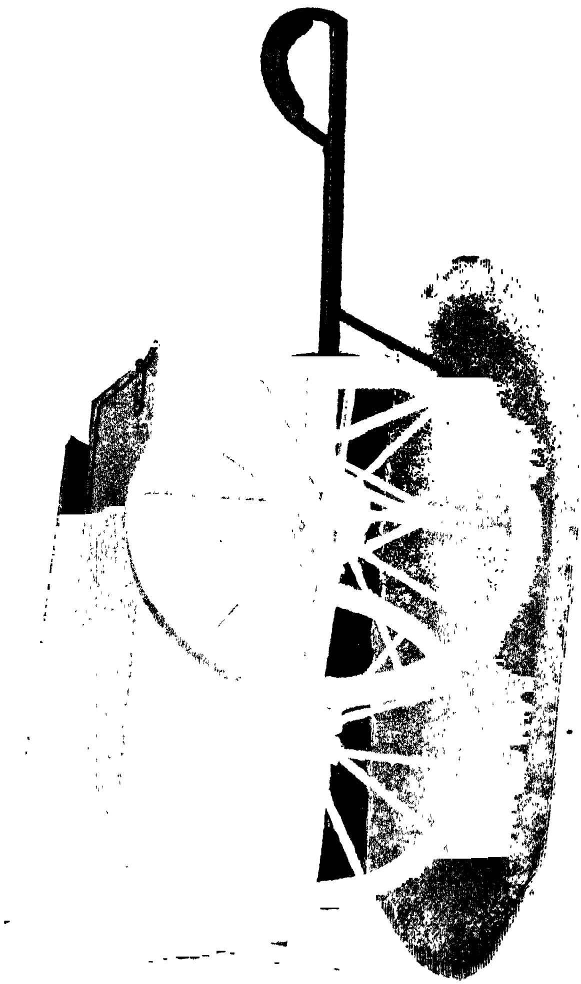

Fig. 22—Covered Refuse Cart.
(*From the Empire Engineering Company, Cawnpore.*)

At the same time it should not be too far away, and should be dry and not subject to flooding. It should be filled up by

successive layers of 2 feet of refuse and 6 inches of earth, until the ground-level is reached. The ground can then be cultivated, and grass and vegetables grown over it.

3. **Sorting.**—This method consists of sorting the refuse in three parts known as breeze, hard core and soft core. What is technically known as breeze should consist of cinders, and small particles of coal ; hard core of bottles, bones, broken crockery and tiles ; and soft core of animal and vegetable organic matters. The breeze is ordinarily utilised by brick-makers in the manufacture of bricks ; the hard core for metalling roads ; and the soft core is used as manure by cultivators. This dilatory method of sorting is, however, likely to prove injurious both to the workers and the persons living in the neighbourhood on account of emanations that are likely to be given off during the process.

SEWAGE.

What is known as sewage, consists of the human excreta, *viz.*, fæces and urine, together with water from kitchens and bath-rooms. All these constituents contain a large amount of decomposable organic matters. The average daily amount of fæcal matter passed by a vegetarian Indian varies from 8 to 12 ounces, while that of urine is about 50 fluid ounces, to which 30 ounces of the ablution water may be added. As regards the disposal of sewage, either of two methods is ordinarily followed, *viz.*, the dry or conservancy system, or the wet or watercarriage system.

CONSERVANCY SYSTEM.

In this system sweepers have to collect fæces and urine separately from privies and latrines, and then to remove them by cartage before they are finally disposed off.

The Privy.—This is meant for private use, and should be situated on the ground floor of a house at a distance of at least 6 feet from a living room, and 40 feet from any well or other source of drinking water. The floor of the privy

should be made of impervious material, such as stone or cement, and raised at least 6 inches above the ground level. The walls should also be made perfectly impervious by a layer of smooth cement. The ventilating opening of an area of two square feet should be placed in the outer wall near the roof, so that it may afford sufficient ventilation and light, when the door is closed. The chamber for the receptacle should be constructed of hard, smooth stone or of bricks plastered with cement, or of any other non-absorbent material. The floor should slope towards a drain so as to cause a flow in that direction. The trap door of the chamber should open outwards on to a space behind the privy to facilitate the cleaning of the receptacle by the sweeper without being seen from outside. This ought to be done twice a day.

The space for foot-rests should not be wider than 9 inches. A moveable receptacle for night-soil having a capacity of not more than 2 cubic feet should be placed 6 inches under the seat to avoid splashing Anti-splash receptacles have been designed for this purpose. It is much better to have an arrangement for receiving nightsoil, and urine and ablution water into separate receptacles, as the separate system prevents splashing, retards decomposition of the fæces, and facilitates the trenching and incineration of the solid excreta.

In some cantonments a solution of perchloride of mercury 1 to 500, or of saponified cresol in the proportion of half an ounce to a gallon of water, is added to urine and fæces before being treated in incinerators along with dry refuse.

The Sandas or Well Privy.—In Northern India an entirely different pattern of a privy, known as *sandas*, is in use. This is usually placed on the upper floor on what may be called a ditch or a small well. It is, however, a most insanitary pattern, as it may cause contamination of the house with effluvia from the accumulated excreta, and may pollute the water of a well in the vicinity through soakage in

the case of high sub-soil water. Wherever possible, these should gradually be replaced by privies of the modern type, while those that are in use should be provided with well-cemented and smooth chimney-like conduits of at least 18 inches in diameter and ventilating openings at the bottom, and the accumulated contents of the sink should be periodically treated with slaked lime.

The Earth Closet.—This is another type of a privy in which the excreta immediately after defæcation are covered with a thick layer of dry earth or ashes, which acts as a deodorant. Good garden loamy soil, brick, earth and dry clay are the best. Sand, gravel and chalk are not good deodorants, and should not be used. In Moule's earth closet the earth is placed in a hopper behind the seat, and on pulling a handle about $1\frac{1}{2}$ lbs. of the earth are thrown over the excreta in the receptacle, and this is enough for the purposes of deodorisation of the excreta of a meat-eater, but for the closet of vegetarians $2\frac{1}{2}$ lbs. of earth are generally required.

The Commode.—This is used by Europeans and Indians living in European fashion. The commode is placed in a bath-room, and consists of an enamelled or porcelain vessel fitted in a wooden box or iron stand. The top of the box or the stand forms the seat, and is fitted with a wooden cover, which, when closed, prevents flies from getting in. Immediately after use the vessel is taken away by the sweeper and emptied into an iron receptacle kept in an out-house of the bungalow. It is then cleaned and replaced in the box. This is a very clean arrangement from a sanitary point of view.

A modified form, known as a receptacle latrine, was used with success during the last Great War in various Eastern war areas. It consists of a wooden seat fitted directly on to an iron bucket. The seat is provided with a fly-proof, self-closing cover, which should fit accurately on to the upper rim of the

bucket. The back support of the seat is carried down to the ground to ensure security to the user.[1]

The Latrine.—Latrines are meant for public use, and are temporary or permanent. The temporary latrines are moveable and are generally used, when people are congregated during short periods as in fairs or camps. The permanent latrines should never be located within 20 feet of any dwelling house, public road or place of public resort, or within 50 feet of any source of water-supply. They are ordinarily constructed in the form of small sheds covered and

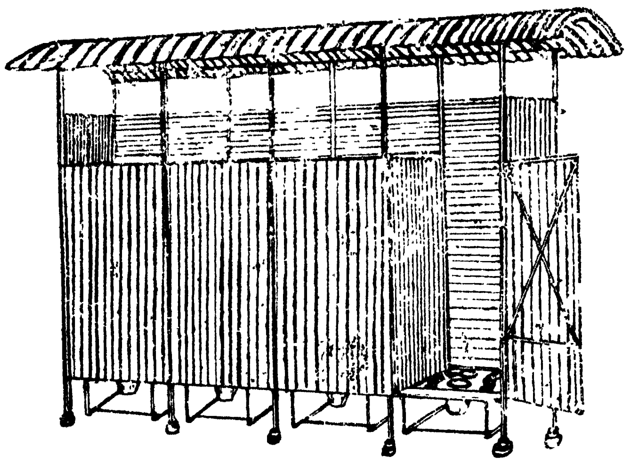

Fig. 23—Latrine.

(*From The Empire Engineering Company, Cawnpore.*)

partitioned with galvanised sheet iron of a corrugated type, and their seats are also made of similar material. Each compartment is provided with a door to ensure privacy, and an improvised socket to hold a *lota* containing water for ablution. The latrine sheds, besides being well covered, should be well ventilated by leaving openings at the top of their enclosure, that may freely admit both light and air.

1. Med. History of the War, Hygiene of the War, Vol. I, p. 188.

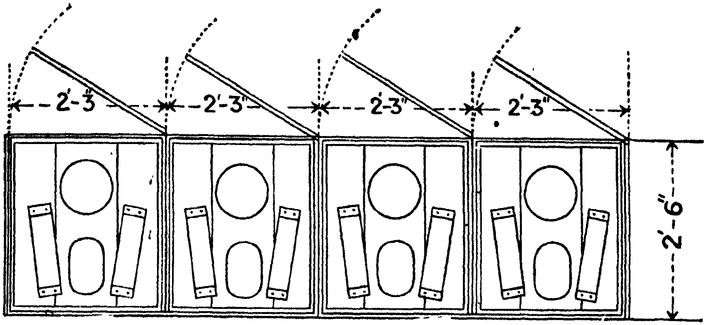

Fig. 24—Plan of Latrine.

(*From The Empire Engineering Company, Cawnpore.*)

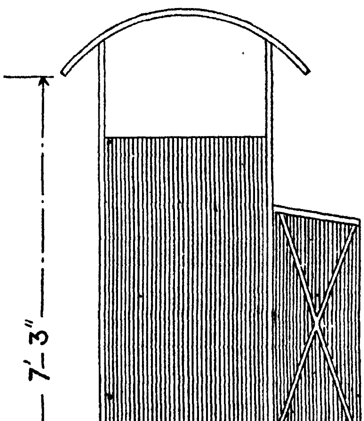

Fig. 25—End View of Latrine.

(*From The Empire Engineering Company, Cawnpore.*)

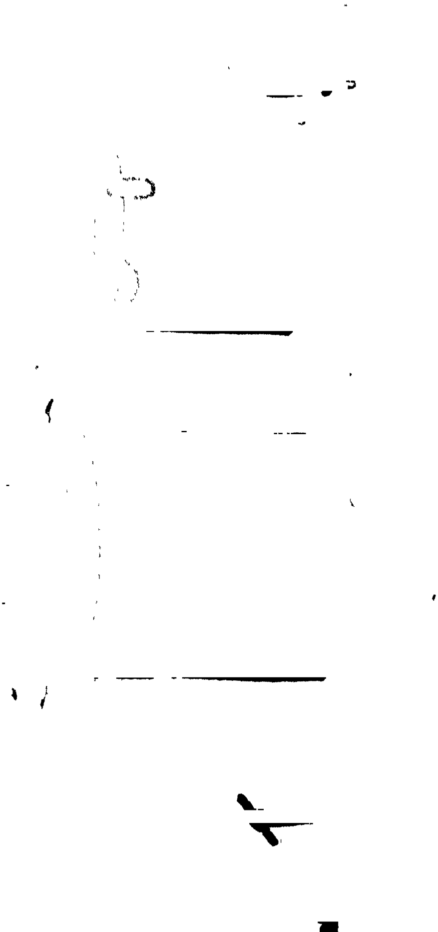

Fig. 26—Night-soil drums or receptacles.
(*From The Empire Engineering Company, Cawnpore.*)

They should be separate for males and females, and should be so constructed as to allow one seat for every thirty residents of a locality.

Latrines should be built either on a hard plot of land or one provided with an impermeable layer or bed of concrete, which should ordinarily be 6 inches higher than the surrounding land. Beneath their seats these latrines are provided with iron or glazed earthenware pans for receiving urine and fæces separately. These pans should be tarred when first made, and then re-tarred every month. The sweepers empty the contents of these into iron drums or receptacles provided with covers, and placed in a convenient position at the back of the latrine. The latter are then emptied once or twice a day into municipal specially constructed filth or night-soil carts, which are then carried well away from habitations and trenched in specially selected sites. These drums should also be kept clean and well tarred.

A drain should be provided along the rear wall of the latrine and inside it to carry away the washings of the latrine, which should be discharged into a municipal open drain. In the absence of a drain the washings may be discharged into a cesspool, which should be emptied by the sweepers into the conservancy cart. The cesspool should be semi-circular in shape, built of masonry and plastered on the inside with Portland cement. The washings may also be led on to a filter bed in a garden, or on to a filter trench located behind the latrine, if it is situated on the outskirt of a town.

In the case of masonry-built latrines, the floor and the walls should be smooth and well polished to allow of easy cleansing. The floor should be made of glazed tiles or bricks and the inside of the walls should be plastered with cement to a height of 3 feet.

Patterns of Latrines.—Several patterns of permanent latrines are used in India. The chief of these, which are considered good and suitable, are Bailey's patent latrine, Donaldson's separation latrine, and Macfarlane's latrine.

Bailey's patent latrine has an arrangement for efficient ventilation, and is provided with double trays, which prevent

saturation and consequent pollution of the soil on which it stands. The only disadvantage is that the seats are very small.

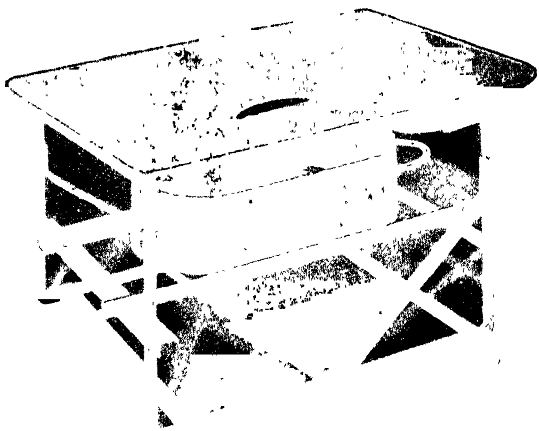

Fig. 27—Bailey's patent latrine seat.
(*From The Empire Engineering Company, Cawnpore.*)

In Donaldson's separation latrine, there is an arrangement for receiving urine and the solid excreta into separate pans, and the drain is closed or open.

Macfarlane's latrine is constructed of cast iron, and is very suitable for the use of railways, workshops, schools, etc. The urine and fæces are separately received into pans, which are provided with closely-fitting lids. These, when full, can be removed and replaced by empty ones. The foot-rests, which are made of iron, are so hinged, that they can be lifted up, and made to rest against the back wall of the latrine.

The Filth Cart.—Filth or night-soil carts are made of iron, have a cylindrical body and have double lids. They have generally a capacity of 12 cubic feet. Of all the different kinds of filth carts Crowley's patent night-soil cart is about the best. It is made entirely of wrought iron. Its body has

a capacity of 75 to 200 gallons, and is fitted with an air-tight lid. It is hung on an axle, so that it is easily tilted over and shoots out its contents on opening the lid. Another variety

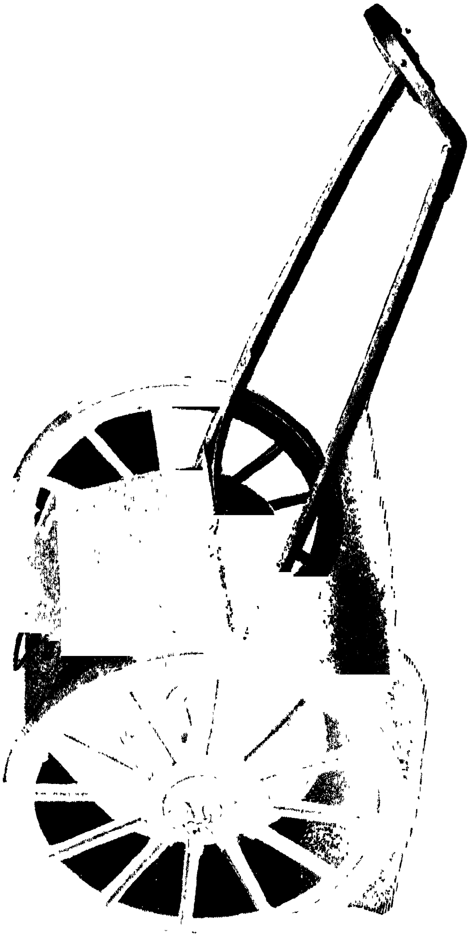

Fig. 28—Filth or Night-soil Cart.
(From The Empire Engineering Company, Cawnpore.)

of a filth cart is known as a receptacle cart. It carries the covered receptacles, when full, direct from the latrines. It is very convenient for groups of small latrines, as it does away

with the nuisance caused by emptying of the receptacles into the carts and spilling the contents.

The night-soil should be removed in these carts after 9 o'clock at night or in the early morning, so that as little

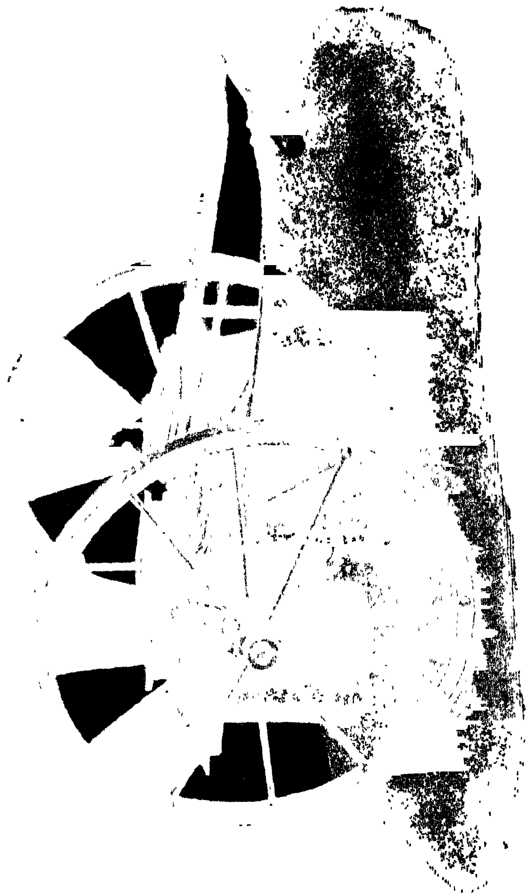

Fig. 29—Receptacle Cart.
(From The Empire Engineering Company, Calcutta.)

nuisance as possible may be caused to the people in the streets But the carts being driven by bullocks or buffaloes are very

slow. Hence light tramways for carrying pails or receptacles are more convenient.

Special precautions should always be taken about the cleanliness of these carts and against any leakage from them. They should be properly washed at the trenching ground before they are brought back at the depôt, where they should be treated both inside and outside by a liquid disinfectant.

DISPOSAL OF NIGHT-SOIL.

The methods adopted in municipal towns for the final disposal of night-soil in the conservancy system are the following:—

1. Trenching.
2. Pitting.
3. Incineration.
4. Selling for the use of brick-kilns.

1. **Trenching.**—The best method of disposal of night-soil is by trenching it in suitable trenches and subsequently disposing of it to cultivators after it has remained a sufficient length of time in the ground.

The Site of a Trenching Ground.—The site for a trenching ground should be carefully selected. The ground should not be low-lying or water-logged, but must be high well above the flood level and properly drained. If such a site is not available, it may be necessary to raise its level above that of the neighbourhood by putting more earth. The earth can be obtained by excavating a tank in the vicinity. The tank can be filled up by rain water, and can then be used for washing the filth carts.

The trenching ground should be loamy and alluvial, but should not be sandy. It should be located on the outskirt of a town, but not to its windward side. It should be at a distance of at least 300 yards from any source of drinking water, and at a distance of 600 yards from human habitations. It should be well concealed from the public view. The approach to the

trenching ground should be easily accessible, and the road should be well metalled for quick carriage.

The necessary plot of land having been selected, it should be properly levelled, drained and divided into 12 equal parts. Each part should be of sufficient size to trench the night-soil for one month. The plot that is once trenched should not be again used for trenching purposes for at least two years. After this time there will be no earth left to fill up the trenches over the night-soil deposited in them.

Systems of Trenching.—The systems of trenching may be described under the following headings:—

(*a*) Deep system.
(*b*) Shallow system.
(*c*) Thornhill system.
(*d*) Allahabad system.

(*a*) **Deep System.**—In deep trenching the trenches should be 2 feet broad and 1½ to 2 feet deep. They should be dug in straight parallel lines and 2 feet apart from one another. Night-soil to the depth of 8 inches to 1 foot should be placed in them, and the trenches should then be filled in with all earth taken out, so that they appear like elevated mounds. These will subside in a few months to the general ground level. Filth thus trenched will usually be resolved into harmless products after six months' burial, but inasmuch as the rapidity with which changes are effected depends largely upon the character of the soil, it is desirable in every case to ascertain by an experimental excavation whether the contents of a trench are dry and inodorous before they are sold. At Nasik trenches are made about 18 inches wide and 18 inches deep, and of any desired length. They are filled with sewage to the height of twelve inches, and are then covered with earth. Owing to the loamy soil of the trenches the sewage loses its offensive smell after a lapse of two or three weeks, when it is readily purchased and used as manure by cultivators.

The length of a trench or trenches occupied by the night-soil of each month should be marked with a small post with the number of the month and the year pasted on it. Separate trenches should not be used for each month, but a post put in on the first day of each month at the point filled in on the previous day.

The area required for deep trenching per 1,000 persons for one year is about 1/3rd of an acre.

Urine is also best disposed of by trenching in a similar manner, or pouring it on to the surface of four plots of land, which are used in rotation. One plot is used for a week, then given two weeks' rest and ploughed before being again taken into use.

(*b*) **Shallow System**.—In the shallow system of trenching the trenches are made 2 feet wide and 9 inches deep with a space of 1 foot between the rows of trenches. These are first filled with night-soil to a depth of 2 inches, and then covered over with dry earth to fill the rest. The sinks are dug by municipal *beldars*, who remain there during the working hours. The land is put directly under cultivation, and a succession of exhaustive crops, such as tobacco and sugarcane, is taken. After the first crop vegetables are grown. The actual area of land required is four times that required in deep trenching, *i.e.*, $4 \times \frac{1}{3} = 1\frac{1}{3}$ acres per 1,000 inhabitants for one year.

This system is used only in a few cantonments. Flies are apt to breed, night-soil being trenched superficially. Again it is necessary to irrigate the land in very dry climates to prevent the particles from being blown away by the wind.

(*c*) **Thornhill System**.—This system is known after Colonel Thornhill, who first introduced it at Bareilly. It is best suited for the treatment of semi-solid matter consisting of night-soil mixed with urine. It consists in digging shallow trenches 16 feet long, 5 feet wide, and 1 foot deep, with a space of 6 inches between each trench and between

each row of trenches. The soil removed is broken up and pulverised, and 2 to 3 inches are returned into the trench into which the contents of one or two filth carts are emptied and immediately covered with the earth excavated. The liquid contents are absorbed. No flies are hatched out. A horse should be able to gallop over these trenches on the next day, and they should be fit for ploughing in three weeks. Rich crops of potatoes and tobacco can be grown by direct cultivation. The land thus treated does not require manuring again for about four years.

This system is very remunerative provided that the Municipal Board owns the land, that the cultivators do not object to the use of night-soil or to work land that has been manured with it, and that there is a sufficient supply of water for irrigation. It may be adopted even in the sandy soil.

(*d*) **Allahabad System**.— This system also deals with the solid excreta and urine and slop water mixed together. It consists in measuring a space, 16 feet long and 5 feet broad, and digging out 3 inches from its top surface so as to make it a shallow trench. The subsoil thus exposed is further dug up, loosened and pulverised to a depth of 9 inches, when a filth-cart containing excreta and slop water is emptied into the trench. The liquid contents of the cart rapidly sink into the loosened soil, and the solid excreta form a thin layer about ¼ inch in thickness at the top. This is covered over with 3 inches of earth removed from another trench similarly dug up in the close vicinity but parallel to the first. The trenches should be put at once under cultivation with grass, millet and sorghum, which should be done without ploughing the ground.

It has been found from experience that night-soil, treated in this manner, decomposes in less than a week. A large area of land, *i.e.*, about four times the area of the shallow trenching, is required in this system, as manuring done once is sufficient to last for four or five years. The chief objection

to this system is the breeding of flies, but this can be prevented by sprinkling chloride of lime or quicklime on the top of the trenches.

To find out whether flies breed in any trench or not, the earth from the trench should be mixed with night-soil and placed in a wooden box. The box should then be covered over with a muslin cloth and kept in the sun. The flies would hatch out in a week's time, if the eggs were present.

2. **Pitting**.— This system for the disposal of solid and semi-solid night-soil is unsatisfactory, unless most carefully supervised. It is employed where private sweepers have the customary right to scavenging. The night-soil is sold direct to cultivators on the understanding that they will pit the material on their own fields.

Pitting should never be carried out within 300 yards of habitations and any source of water-supply. Ordinarily pits are made about 20 feet square and 4 feet deep, and are filled with night-soil. The night-soil, which is also mixed with urine and slop water, undergoes fermentation and decomposition by the heat of the sun, and emanates an offensive smell. When it becomes dry, it has already lost its fertilizing power due to the gases of decomposition. It is, therefore, necessary, that the pits should be at most 5 feet wide and 3 feet deep. They should never be more than 3 feet deep, as there are very few nitrifying organisms in the soil below this depth. A layer of earth should be placed over each cart-load of night-soil after it is deposited into the pit. Each pit should also be covered over with a foot of earth. If treated in this way, the night-soil will be fit for manure after 3 months, but will lose its fertilizing value, if allowed to remain too long.

In the Nasik system of pitting night-soil devised by Lieut.-Col. Majoribanks, I.M.S., pits are covered with a layer of town refuse only, after the night-soil in its crude and liquid form has been deposited in them. The process of drying and ripening of the night-soil occurs gradually, and after a

year or so the contents look like ordinary earth, and are taken away by cultivators for manuring their fields. This method is used throughout the year.

3. **Incineration.**—This is most suitable in cantonments, jails and hospitals, where a separation of liquids and solids is carried out, and where a sufficient supply of dry fuel is available. The rainfall should also be small. The incinerator is either placed near the public latrines it is to serve, or near the pail depôts or *dalaos* made at convenient places near the habitation, where the sweepers take the night-soil mixed with house refuse from private houses. There should be a sweeper in constant attendance. It is necessary, therefore, that his quarters must be constructed near the incinerator. A shed for the collection of dry fuel should be constructed near the incinerator, and a water-tight masonry-built platform for mixing up the fuel with night soil should also be constructed. It is desirable to enclose the whole with a compound wall. The night-soil should always be placed on the fire in small quantities, and not in bucketfuls.

4. **Selling for Use in Brick Kilns.**—The selling of night-soil mixed with rubbish for use in brick kilns is most objectionable. The night-soil accumulates in large quantities until the kiln is ready for firing and breeds out flies, and the danger is obvious, since the kilns are often in the midst of towns near a populated locality. The practice may, however, be tolerated in cases where the kiln is situated at least half a mile from a populated area, but only when the cleanliness of the surrounding area is ensured and the actual firing is likely to be quickly carried out.

URINALS.

People are in the habit of committing a nuisance by passing urine in lanes or at the corner of a street or even the back wall of a house. Hence it is very necessary that proper urinals should be constructed at convenient places in too-frequented streets and *bazaars*, and the people should be

enjoined to pass urine at those urinals and nowhere else. For this purpose a cart urinal or a cantonment urinal can be used. In the cart urinal a receptacle of a convenient size rests on a masonry floor, and is placed under a raised and enclosed platform on which the squatting seat is fixed. The receptacle, when full, can be easily removed and replaced by an empty one. It can then be carried to a trenching ground.

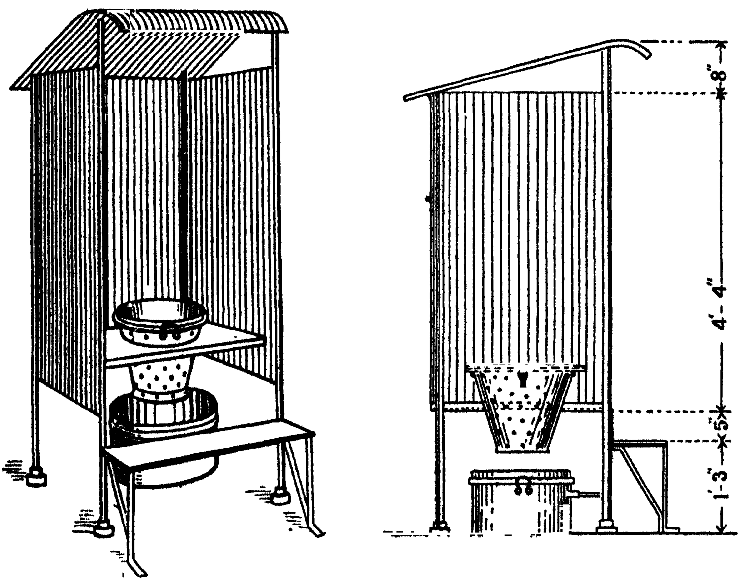

Fig. 30—Cantonment Urinals.
(From The Empire Engineering Company, Cawnpore.)

The cantonment urinal is a cheap and sanitary type of urinal and is largely used in cantonments. It consists of two galvanized pans, one below the other. The upper one is perforated and contains saw-dust through which the urine trickles as an inoffensive liquid into the lower pan. The saw-dust should be periodically removed and burned.

Another type[1] of a urinal known as "model closed urine pit", and used in Indian cantonments was successfully used during the last Great War in various districts, more especially in Egypt. It consists of a pit varying from a four feet to a ten feet cube dug in the ground, and filled in with stones, brickbats or perforated tins graded so that the smaller sizes are at the top of the pit. It should be noted that in the pits used in Indian cantonments small stones are placed at the bottom, and the larger ones at the top, so that the liquid evaporates more rapidly, or is better distributed into the soil. Pipes improvised from waste tins are then inserted deeply into the pit and communicate with funnels or troughs which form the urinal. The liquid urine is soaked into the surrounding soil, where foul material is destroyed by bacterial action. These pits do not give rise to any nuisance or danger, if there is no source of water-supply in close proximity. The value of these soak pits depends very largely upon the permeability of the surrounding soil. In sand the pit may last indefinitely without causing any nuisance, while in clay it may fill up quickly with urine, and give off offensive smell owing to the decomposition of the collected urine.

SULLAGE FARMS.

In the conservancy system the slop water from kitchens, bathrooms, etc., is carried away by municipal surface drains constructed along the sides of the roads. These are constructed of stone or some non-absorbent material, and are shallow with a rounded bottom, so that they can be easily cleaned. In lanes and near houses they are very often used by children for defæcation, and all sorts of filth are also thrown by the people. Hence it is very essential that they should be cleansed and thoroughly flushed twice a day. The sullage water from the drains is discharged into rivers at some places, but, where possible, it should be utilized for

1. Official History of the War, Medical Services, Hygiene of the War, Vol. I, p. 223.

growing crops, as it usually contains a large amount of nitrogen, and is a most valuable fertilizing medium. In small towns without a piped water supply in the irrigation of crops with sullage the "ridge-and-furrow" principle should be adopted, as the direct application of strong sullage burns the vegetation. In cases where there is not sufficient fall, sullage water can be lifted by baskets and the land irrigated. Waste land so irrigated becomes very fertile.

WATER-CARRIAGE SYSTEM.

In adopting the dry system of conservancy the excreta have to be collected and kept for some time before their final disposal ; the chief disadvantages of this system are (*a*) the accumulated excreta unless kept well covered are liable to attract flies, (*b*) the cost in the matter of keeping a large supply of carts and bullocks and a staff of sweepers is likely to prove prohibitive, (*c*) a proper disposal of them will, in spite of a careful arrangement, have to depend on the efficiency and carefulness displayed by the staff of sweepers which, as not infrequently happens, may go on a strike, on pretences of various imaginary or real grievances. The water-carriage system is, therefore, the more preferable which enables a more independent disposal of solid and fluid excreta, as also of sullage water. The latter has been adopted in large cities in India, provided with a plenty of supply of water through installations of water works, but is yet unsuited for smaller cities and towns which have no sufficient watersupply.

SANITARY APPLIANCES.

The chief sanitary appliances necessary for the water-carriage system are water-closets, soil-pipes, house drains and sewers.

1. WATER-CLOSET.

This is an apartment in which the sanitary apparatus or closet for receiving the excreta is generally placed. It also contains a separate cistern for flushing purposes. The water-closet should be constructed outside of the main wall, and

connected with the house by a short lobby, which should be properly lighted and ventilated. The closet and lobby should have separate doors. The walls should be smooth and plastered inside with cement or varnished with paint

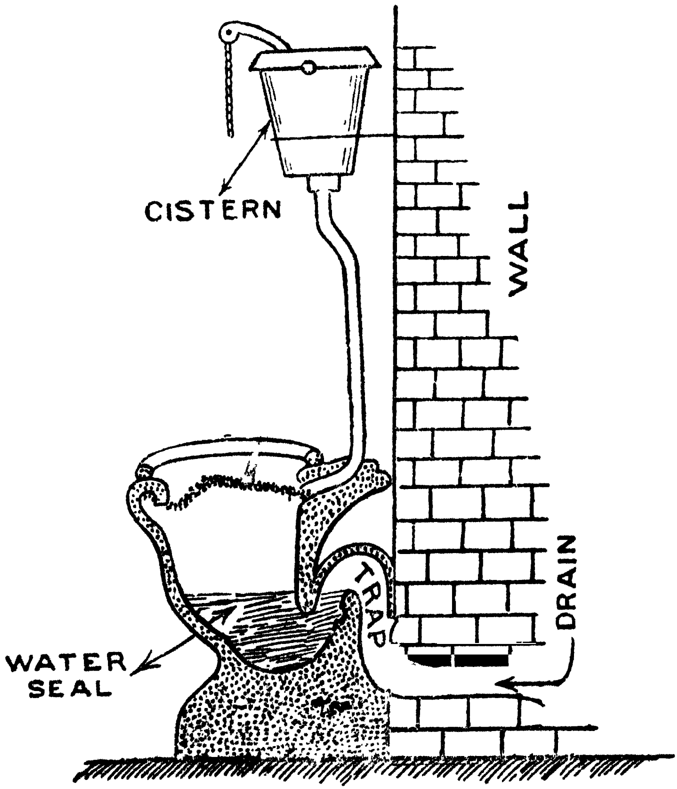

Fig. 31—The water closet with a cistern.

or should be made of corrugated galvanized iron sheets. One of the walls should be an external wall abutting on an open space, and should have a window or grating at least 2 feet by 1 foot in area opening directly into the external air. In many-storied buildings as met with in large commercial towns

the water-closets should be constructed one above the other forming a turret detached from, but within easy access of, the main habitable blocks.

Closet.—The closet is a basin or pan of some such impermeable material as glazed earthen-ware or stone-ware, and is made of such a shape and capacity as to receive and contain a sufficient quantity of water and to allow the dejections to fall directly into the water without splashing against its sides.

Types of Closet.—There are two chief types of closets, *viz.*, those in which there is no moveable apparatus for retaining water in the basin, and those in which there is a moveable apparatus for such purpose. The various types of the hopper closets belong to the first type, and pan, valve and plug closets belong to the second type.

Of all these varieties the best and the cheapest is the short hopper or the wash-down closet, in which the basin and trap are made of one piece and not of separate pieces as in long hoppers. The basin is conical in shape and constructed of glazed stone-ware or porcelain, and provided with a flushing rim, which washes its sides and keeps it clean. To avoid soiling the posterior wall of the basin is made vertical, whilst the anterior wall is oblique. It is connected below with a siphon trap—a bent tube always containing a column of water technically known as a water seal.

The Modified Indian Type.—In India the majority of the people are in the habit of squatting at the time of defæcation, and therefore the basin or the pan is arranged with two foot-rests, one on each side almost flush with the floor of the closet, which is generally made of hard, smooth and impervious material, such as stone, tile or cement having a fall of half an inch to the foot from all sides towards the seat. The superficial area of the floor should be 9 square feet (3 feet by 3 feet) as far as possible, and should never be less than 6 square feet.

The basin is made either of Doulton, Hindustan or Oriental pattern, or is made of cement in the shape of the same patterns. The outlet of the basin is so arranged that it may be a little hinder than the posterior rim of the basin. The splashing of the water in the trap at the time of deposition of the dejecta is thus prevented.

If the basin is made of cement, it should be provided with a perforated lead ring $1\frac{1}{8}$ inches in diameter going round the rim of the seat.

Cistern.—For flushing purposes the water closet should be furnished with a tank or cistern placed against the wall at a height of 4 to 5 feet above the closet made of galvanized iron, slate or zinc, and provided with a cover to prevent ingress of the dust, flies and mosquitoes. It has a capacity for holding 3 gallons of water, and is connected with the posterior part of the flushing rim of the closet below by means of a lead supply pipe, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. It should, on no account, be connected with storage water tanks used for drinking purposes.

The cistern is usually supplied with a ball trap to regulate the admission of water, and provided with an overflow-pipe. The working of the cistern depends upon automatic siphonic action, so that every time the chain is pulled, only 3 gallons of water (its capacity) are discharged. Hence it is commonly known as the water-waste preventer.

In cases where some of the high class Hindus object to touch the handle of the chain, flushing of the closet may be effected by the siphon cistern acting periodically and automatically by the action of lever on opening or closing the door, or by closet-seat action, which comes into operation, when the man leaves the seat. All these three arrangements are not satisfactory, as they cause a large waste of water and are liable to get soon out of order.

Trap.—To prevent the reflux of foul gases an efficient trap capable of maintaining a water-seal must intervene

between the pan and the soil-pipe to which it is connected. The pipe beyond the trap must be ventilated.

Trough Closet.—A typical form of this variety of closet consists of an open long trough made of stone-ware, galvanized iron, or glazed earthen-ware divided into compartments placed on an inclined plane sloping at one end and furnished with a weir towards the drain that remains filled

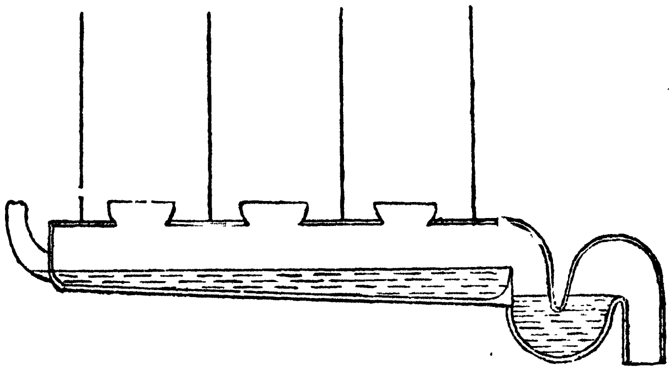

Fig. 32—Trough closet
(After Parkes and Kenwood.)

with water to receive the excreta. This form of closet is particularly suited for a large collection of people as in boarding schools, asylums, workshops and factories. Its chief disadvantage lies in the fact that unless automatic flushing is provided for, its efficient working has to depend altogether on a staff of menials.

An improved type of trough closet has lately come into use. In this type each compartment has a separate basin, the outlet from which dips into the water in the trough. There is no weir but a high siphon trap at the end, so that water always remains in the trough.

Slop Closet.—This is a form of closet, which consists of a wide vertical shaft placed over a large siphon trap, so that the excreta fall into the water of the trap and are flushed

out by the waste waters of the house. These are collected into a tipper, an earthenware vessel having a capacity of about 3 gallons, which automatically discharges its contents when full.

Sinks.—These are the appliances provided for receiving waste waters from the kitchen and the pantry. These are best constructed of enamelled iron or earthenware, and provided with grease traps to prevent the fittings or the drain from being choked. They should be placed in the open to allow of cleansing and should not be surrounded by wood work, which is likely to get sodden and accumulate dust and other decomposing materials.

The contents of the sinks and the waste water from the baths, etc., should be made to discharge into a main waste-water pipe through trapped and ventilated waste pipes. The main waste-water pipe should open into a ventilated disconnecting trap before it enters the house drain.

Urinals.—These should be constructed of non-corrosive and non-absorbent material, such as stone, slate or fireclay, and should be flushed from a cistern, which works by siphon action automatically at regular periods. They should be connected with a soil-pipe by means of a siphon trap.

2. SOIL-PIPE.

This is a conduit that is connected at one end with the closet or urinal trap by means of what is known as Doulton's ceramic joint, and at the other with the house drain by means of a brass ferrule. It should only convey the discharges from water-closets and urinals, but under no circumstances must be made to carry the discharges from sinks or baths. It should be circular in shape, and have an internal diameter of 3½ or 4 inches. It is ordinarily made of cast or galvanized iron or drawn, milled or rolled lead, about 8 or 9 pounds per square foot. To prevent oxidation and the formation of rust the iron soil pipe must be protected both inside and outside

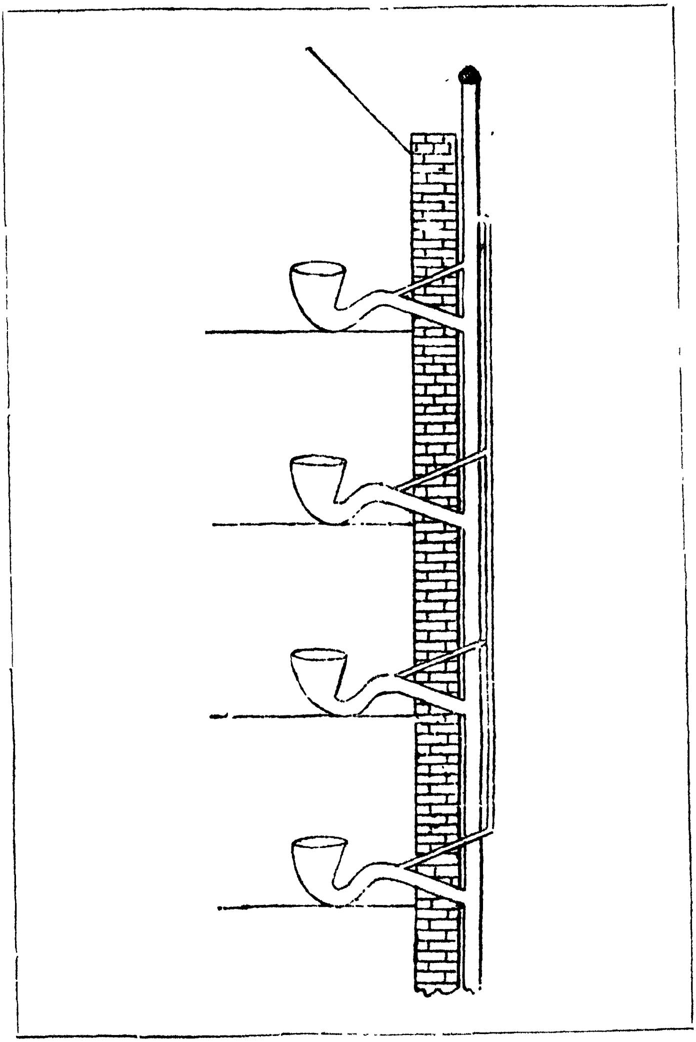

Fig 33—The soil-pipe and ventilator with anti-siphonage pipes.
(After Parkes and Kenwood.)

by a coating of the magnetic oxide of iron (Barff's process), hot coal-tar pitch or Angus Smith's preservative consisting of

pitch, asphalt, oil and tallow. The pipe is usually ten feet long, and the joints are calked with lead, but in the case of the lead pipe the joints are wiped or soldered.

The soil pipe should be placed against the outer wall of the house, so that it may easily be inspected and extended beyond the roof, and well away from windows, chimneys and sky-lights for purposes of ventilation. To allow a free circulation of air and the escape of foul gases generated, the lower end of the pipe should open over a disconnecting trap outside the house, and the upper end should be carried at least 5 feet above the roof of the house, and should either be left open or covered with a wire gauze dome.

Prevention of Siphonage.—When the soil-pipe happens to be common for the closets constructed for the different flats of a several-storied house and placed one above the other, there is always a risk of the water being sucked or siphoned from the traps of the lower closets, when the upper ones are flushed. This siphonic action can be prevented by carrying a ventilating pipe, full bore, from the upper and distal parts of each trap or by carrying anti-siphonage pipes from beyond the trap of every closet through the house wall and connected with a vertical pipe, 2 or 2½ inches in diameter, placed alongside the soil-pipe. This vertical pipe should open above into the soil-pipe, after it has received the anti-siphonage pipe from the highest water-closet.

3. HOUSE-DRAIN.

The house-drain is a pipe intended to convey the waste water and water-closet discharges from the soil-pipe to the sewer. The requirements of an efficient drain are that it should be absolutely water-tight, its interior should be perfectly smooth to prevent accumulation of filth, and all its branch connections should be made at acute angles and in the direction of the flow. It should also be provided with inspection openings at convenient intervals, should be laid in straight lines and should have a definite and uniform gradient,

The house-drain is usually constructed of glazed stoneware or earthenware pipes with cemented joints, but it is constructed of cast-iron pipes, in 9 feet lengths and jointed with lead, when the ground is soft or when the pipes are likely to be subjected to considerable strain. The cast-iron pipes should be coated on the inside and outside with a non-corrosive material like magnetic oxide of iron.

The house-drain should always be laid on an impermeable bed of concrete to prevent the joints opening if the soil were washed out from beneath. It should have a sufficient gradient to ensure easy and thorough flushing with a velocity of flow of 3 feet per second. The gradient varies with the diameter of the drain in the ratio of 1 in 10. Thus the usual diameters of drains are 4, 6 and 9 inches, and their gradients would be 1 in 40, 1 in 60 and 1 in 90, respectively. It should be noted that a small drain is more capable of self-cleansing than a large one, but it should be wide enough to prevent blocking of sewage and to carry off all the sewage of the house as well as all rain water.

The house-drain should not pass through or under a house, but if this is not possible, it should be made of cast-iron pipes, should be surrounded by a 6-inch layer of concrete, and should be provided with disconnecting man-holes at each side of the house as a means of easy access.

Disconnection of House-Drain.—The house-drain should be disconnected from the sewer by an efficient intercepting or disconnecting ventilating trap. This trap prevents the reflux of foul gases from the sewer and the entrance of sewer rats into the house-drains, but allows a free circulation of air through the drain and soil-pipe. It is usually placed at the bottom of a man-hole or disconnecting chamber, immediately before the house-drain leaves the private property, and enters the public thoroughfare. The house-drain should be ventilated at intervals by air shafts passing up to gratings at the surface of

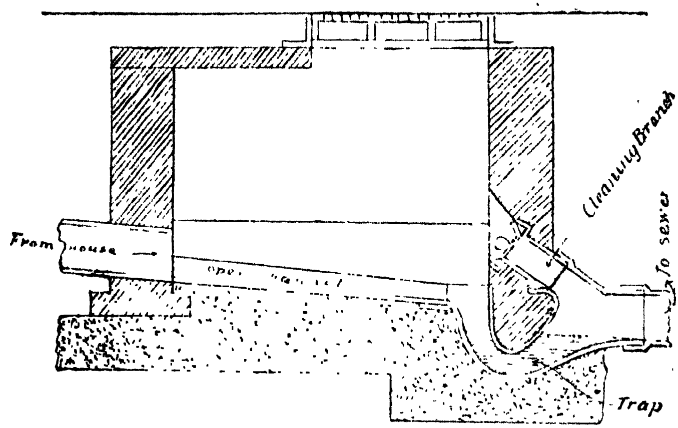

Fig. 34—Disconnecting Chamber.

the ground, or these may be carried up the side of the house to prevent nuisance.

Traps.—These are intended to prevent the reflux of the foul-smelling gases of decomposition from the soil-pipe or house-drain from entering into the house, though they allow the onward passage of wastes. A trap in its simplest form is merely a pipe bent more or less into the shape of a U which always retains a certain quantity of water, and thus prevents gases from passing through. The column of water lying in the bend is known as the "water-seal" or "water-lock," which is the distance between the upper surface of the water in the trap and the point where the bend of its smaller curvature begins.

A trap is apt to be unsealed or get out of order, (1) by evaporation of water due to the bend being too shallow or from disuse; (2) by accumulation of solid matters due to faulty construction; (3) by momentum of the flushing water being maintained to the very end of the flushing; (4) by the backward passage of gases when the drain is not ventilated; and (5) by siphon action. A good trap for house fittings should be constructed of strong, smooth, non-absorbent material, should be free from all angles and corners so as not to allow readily

the accumulation of filth, should be self-cleansing and should have a water-seal at least 1½ to 2 inches in height. It should be fixed straight in a perfect level, so that it may not be converted into a cesspool. It should also have an opening in the form of a brass screw plug at its lower end for inspection or cleansing purposes, and should have a ventilating opening equal in diameter to that of the soil-pipe.

Forms of Traps.—Traps vary in their forms according to the positions where they are fitted up in the drainage system of the house. The best and the safest traps are those which are known as siphon traps. These are also called P. or S. traps according as the outlet passes directly outwards or downwards. These are usually fitted to closets, sinks and

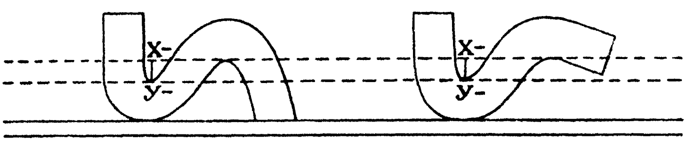

Fig. 35—Trap.
(After Parkes and Kenwood.)

baths. D-traps fitted to pan closets are very large, and are easily corroded and eaten into holes by the excreta. Hence they are now condemned. Mid-feather traps are also unsuitable as they are not self-cleansing. They are made of round or square boxes with inlet tubes on one side and exit tubes at the other side, but at the same level. Water stands upto the lower margin of each tube and a partition passing down into the water is interposed between the two. Bell traps and Antill's (lip) traps are likewise undesirable, as they are easily choked up, and get out of order.

Flap traps are hinged flaps or valves, which allow water to flow in one direction only. They are used to close the mouth of sewers, to prevent influx of wind or water, and thus prevent regurgitation.

Grease traps are fitted to kitchen sinks with a view to prevent the choking of the drain by the grease collecting and congealing in it. The traps are made of earthenware or iron and contain a large volume of water, which allows the grease contained in it to float to the surface and solidify, and thus arrests its inward flow, while allows the dirty water to flow away from beneath it.

Gully traps are interposed between rain water and waste pipes and the underground drains. They are strongly made of iron, are placed in courtyards at a distance of 18 inches from the wall of a house, and are intended to arrest the solid suspended matters in their downward passage, and allow the rain and muddy water to flow off to the sewer. The most convenient of these traps is Dean's gully trap. It contains a moveable bucket-like receptacle for solid matters, which can be emptied periodically by removing the bucket by means of a handle.

Intercepting traps are made of glazed earthenware, and are placed between the house-drain and the sewer. These are usually large and are placed at the bottom of the man-holes. Buchan's, Weaver's and Hellager's intercepting or disconnecting traps are some of their varieties.

Testing of Drainage System.—The efficiency of all the fittings of the drainage system in the house has frequently to be tested after laying a new house drain and periodically in the case of all old ones. The tests which are ordinarily applied are the following :—

1. Water test.
2. Smell test.
3. Smoke test.
4. Pneumatic test.

1. **Water Test.**—This test is applied to newly laid and jointed drains before they are embedded in concrete. It is carried out by plugging the lower end of the drain in the disconnecting chamber with a suitable water-tight stopper, and

then filling it gradually with water. If the water level remains stationary for an hour or two, the drains under observation are sound and water-tight. But the level of the water will be found to be lower, if there is any defect in the drains. In that case the joints of the drains should be carefully examined to detect leakage in the drainage system.

2. **Smell Test.**—This is applied by pouring boiling water containing peppermint oil into the water-closet. In the event of a leakage the menthol fumes will get regurgitated into the house. This test can also be performed by employing calcium phosphide which, in the presence of moisture, evolves phosphoretted hydrogen gas known by its characteristic garlicky smell. The calcium phosphide is put up in a small closed box to which a string is attached. The box is placed in the trap of a water-closet which is flushed with water from the cistern. On pulling the string the box is opened, and the gas evolved will escape through the joints, if any of them are leaky.

3. **Smoke Test.**—This test is applied by burning waste cotton dipped in tar or by igniting smoke rockets in the drain after the top of the ventilating shaft is closed. The waste cotton gives off very pungent smoke, and the smoke rockets give off dense volumes of smoke, as they contain sulphur. If the doors and windows are closed, the smoke will be noticed escaping in the house, if any of the joints are faulty or leaky. The smoke can also be pumped into the pipe by means of a special bellows (Eclipse smoke generator). The test is commonly applied to underground drains, vertical soil pipes, or drain-ventilating pipes.

4. **Pneumatic Test.**—This is very similar to the smoke test and consists of air being forced into the drain or soil pipe by means of a pump under pressure. Any leakage is noted by a change in the level of manometer attached to the generator. It is a very searching test, for it reveals the presence of a leakage, but fails to locate it owing to the escaping air being odourless and colourless.

4. SEWERS.

These are the channels intended to receive discharges from several house-drains and provided with man-holes and flushing gates for the purposes of inspection and cleansing. They may belong to either of the two systems, *viz.*, separate or combined. The separate system necessitates a provision of two sets of sewers, one for receiving rain and storm water, and the other for household sullage matter. The great advantage of this is that the sewage is concentrated and uniform in quality and quantity, and can be used directly for irrigation, etc., but the chief disadvantage is of the cost and the difficulty with which the separate systems are to be maintained and the danger of joining the house-drains to the rain-water sewers, or *vice versa.*

The combined system has a common sewer to carry away both sewage and rain-water. The sewers must be large enough to carry away the largest amount of water, or some method must be adopted to prevent them running quite full, or else they are apt to burst. It should, however, be noted that in India where the rainfall is periodic and limited, the combined system cannot generally be adopted.

Sewers are placed underground, usually at a distance of ten feet from the surface of the road, on a bed of impermeable concrete, straight in their course as far as possible, and provided with an easy gradient for efficient flushing, and jointed with others obliquely to prevent clogging.

Sewers up to 18 inches in diameter are constructed of glazed earthenware or iron pipes and are circular in shape. Sewers of a larger diameter are made of glazed bricks or cement, and are of an oval or egg shape, the narrow end (or invert) being placed below, and the broad end forming the top or the crown. Their size depends upon the amount of sewage, rainfall and the available gradient. Under no circumstances, however, should a public sewer be less than 9 inches in diameter.

The gradient for sewers should be sufficient to produce a velocity of not less than 3 feet per second in India, so that the sewage may be quickly carried away without leaving any deposit of silt at the bottom or invert. The larger the sewer the less will be the gradient to produce the same velocity. Hence a sewer, 10 feet in diameter, should have a fall of 2 feet per mile, a sewer, 5 feet in diameter, should have a fall of 4 feet per mile and a sewer, 1 foot in diameter, should have a fall of 20 feet per mile. With such a gradient the sewage is ordinarily capable of being conducted away to its outfall by gravitation; but when a sufficient gradient cannot be obtained in flat and lowlying districts, pumping has to be resorted to for lifting the sewage from a lower level to a higher level. This is effected by Shone's system or by Liernur's system.

Shone's System.—This is a system in which compressed air from a central station is used as a motive power for raising the sewage. It consists of ejectors or cylindrical reservoirs, which are made of cast or wrought iron and have an inlet and outlet pipe for the entrance and exit of the sewage, each pipe being provided with a ball-valve, and the inlet pipe having the shape of a siphon. The ejectors are situated underground in brick-work chambers or in cast-iron tubings at different parts of the town to receive the sewage from the street sewers. When the ejectors are filled with sewage, compressed air is injected from tubes carried along the upper surface of the outside of the reservoir by means of a float acting automatically on a counterpoised lever. The effect of the entrance of compressed air is that the inlet valve closes and the outlet ball-valve opens so that the contents of the reservoir are forced out into a gravitating sewer at a higher level. The compressed air escapes through a ventilating shaft, and mixes with the atmospheric air, as soon as the ejector is empty, and thus it is ready for a fresh charge. This system has been adopted in Southampton and other towns in England, and has been in use for some years in Bombay and Karachi. But

in cities where there is a heavy rainfall considerable difficulty is experienced in coping with the increased flow of sewage in the sewers owing to the passage of rain water from open drains, etc. It is, therefore, necessary to arrange for storm overflows from the sewers, wherever practicable, so that the system may work efficiently.

Liernur's System.—In this system the motive power for conducting the sewage is also compressed air. It is supposed to be well suited to towns where the water-supply is limited, and where a sufficient gradient for sewers cannot be obtained. It has already been adopted in Amsterdam and other places in Holland, France and South Africa. The system requires two sets of channels, one for conducting away storm water, and the other for sewage. The water-closets of a number of houses are connected by means of hermetically closed iron pipes with an air-tight tank, which is periodically exhausted of air, so that the excreta are drawn into it. These tanks are placed underground at different parts of the town, and are connected by means of pipes with the central air compressing machinery, by means of which the contents are drawn at intervals into a steam concentrator at the central pumping station, where the sewage is converted by boiling and evaporation into a dried solid sludge or poudrette. This poudrette is then sold as a manure.

Manhole.—This is a side entrance into a sewer provided at intervals of 100 yards throughout its course especially at points of divergence. It consists of a masonry chamber down to the sewer, through the centre of which the main sewer runs and through the sides of which the branch sewers open. It is wide enough to allow of easy ingress and egress for purposes of cleaning and inspection, and is provided at its street end with a pair of well fitting iron doors. It is better that it should be provided with gratings for ventilation.

Flushing Gate.—This is a contrivance placed generally at the ends of sewers for purposes of efficient flushing and to prevent stagnation of sewage matter at its bottom. It is

automatic in its action, and covers the whole or a part of the sewer end. When closed, it draws back the flow of the sewage which, on opening it, escapes with a rush and thus cleans the sewer as well. The wider upper part of the sewer does not, however, get cleansed by this flow at its lower end. Hence a separate arrangement will have to be made for its periodic cleaning by means of automatic flush tanks supplied from mains in cities provided with water works, or through the agency of water carriers or *bhistees* in towns unprovided with such. The sewer may also be flushed by pouring a large volume of water into it through a manhole.

Air in Sewers.—In properly constructed sewers, where there is no obstruction to the downward flow of the sewage, the air will not vary greatly from the outside air except that it may contain a higher percentage of carbon dioxide and organic matter. However, in old and badly constructed sewers, and even in fairly good ones during the summer when the water-supply is scarcely sufficient, sewage will not flow away rapidly, but will be deposited to the sides and bottom, causing stagnation. This will cause putrefaction of the sewage and give rise to noxious gases, sush as carbon dioxide, marsh gas, hydrogen sulphide, ammonia, carburetted hydrogen, etc. The temperature of the sewer air is lower than that of the atmospheric air in tropical countries.

Bacteria have a tendency to adhere to the damp surfaces of the internal walls of the sewers, and are, therefore, prevented from floating in the sewer air. In 1907 Horrocks found from his experiments that the specific disease germ, *e.g.*, Bacillus *prodigiosus*, may be disseminated into the sewer air by means of bursting of gas bubbles produced by fermentation, and may be transmitted into the outside air, thus proving a source of danger to health. Winslow repeated Horrock's experiments in 1909, and found that such infection was very limited and localized, and the air of house-drains was singularly free from bacteria.[1]

1. M. J. Rosenau, Preventive Med. and Hyg., Ed. IV, p. 951,

Ventilation of Sewers.—Sewers should be provided with an efficient means of ventilation at intervals of hundred yards to provide for an easy escape of noxious gases and effluvia resulting from the decomposition of sewage. This is ordinarily secured by means of iron outlet shafts connected with the crown of the sewer at the street level and covered by an iron grating. Beneath the grating is placed a moveable tray or dirt box with a space round about for a free passage of air, into which are received gravel, stone, mud, etc., which would otherwise fall into the sewer. These open grids are objectionable, as they discharge the offensive gases from the sewer more or less immediately under the noses of the foot passengers. Hence iron shafts should be fixed to the sides of the neighbouring houses, and should be sufficiently high to allow the escape of air and gases well above their roof level. The top of the shafts is usually covered with aspirating cowls. Street gullies should, at the same time, be efficiently trapped to prevent mud, sand, stone, etc., from entering the sewer. It should, however, be borne in mind that there would be no accumulation of foul gases, if sewers were properly constructed with a sufficient gradient, and were daily flushed with a sufficient quantity of water. Decomposition generally occurs at dead ends, which should not be tolerated by sanitary engineers.

Various forms of deodorising apparatus have also been adopted in some places for the purpose of purifying the air of sewers. Charcoal trays placed in the ventilating shafts of sewers are useless as charcoal is non-absorbent, when wet. The simultaneous discharge of sulphuric acid and potassium permanganate as in Reeve's apparatus liberates the oxygen which, in its turn, oxidises the organic effluvia and renders them inodorous. In other cases gas lamps are kept burning continually in the ventilating shafts, or the street lamps are used as vent shafts, fans and ejectors (Webb's system).

Accidents in Sewers.—Workmen who enter parts of a sewerage system for cleansing them are sometimes overpowered or killed by asphyxiating and poisonous gases

emanating from the sewer. The chief danger is at the dead ends, manholes and similar places, where the poisonous gases can collect owing to lack of sufficient ventilation. The Sanitary Inspector in charge of cleansing operations should, therefore, strictly follow the following procedure before he sends his men into covered sewers[1] :—

(1) Ventilators should be inserted into the sewer at convenient places as soon as the manholes are opened. The ventilators should be placed in such positions as shall give the men below the fullest advantage from the fresh air drawn into it. Two hours after the manholes have remained open the state of the atmosphere in the sewer should be tested by the Inspector in the following manner :—A lighted kerosene oil lamp of the ordinary hurricane pattern should be lowered into the sewer close to the water or silt, and the silt agitated, and the lamp kept there for at least fifteen minutes. If the flame of the lamp burns clearly and steadily, the Inspector may assume that the air in the sewer at this place is sufficiently pure to permit of the entrance of the work-people. But only down such manholes as have been so tested should men be sent into the sewer.

(2) The first man to enter the sewer should have a lamp in his hand, and he should proceed cautiously along the sewer towards the next manhole for a distance of twenty yards, carefully observing all the time whether the lamp burns brightly or not, and then suspend the lamp in the sewer by such means as are convenient.

(3) As a rule, all sewers should be cleaned by working with the flow of sewage, and all possible expedition should be used in carrying out the work by sending gangs of men into the sewer at different places. Each gang should work between lamps. On any lamp going out, the men should at once come out of the sewer by the nearest manhole.

1. Turner and Goldsmith, Sanitation in India, Ed. III, pp. 193, 194.

(4) The gang working in the sewer should not be allowed to remain down longer than half an hour at a time. This gang should come up for rest, and another gang should be sent down in its place.

(5) If any man happens to become ill in the sewer, he should, with the least delay be brought to the surface of the ground, and artificial respiration should be resorted. After breathing is restored, warmth should be applied to the body and circulation promoted.

FINAL DISPOSAL OF SEWAGE.

The sewage of towns carried by means of the water-carriage system may be disposed of finally in one of the following methods :—

1. Discharge into the sea.
2. Discharge into rivers.
3. Disposal after rendering purification.
4. Disposal after biological treatment.
5. Disposal by direct land treatment.

1. **Discharge into the Sea.**—This is the readiest and best way for the disposal of the sewage of towns situated on the sea side. The end of the sewer should be provided with a flap valve and placed well below the lowest level of the ebb-tide, so that the discharge may not be driven back on the foreshore during the incoming tide.

2. **Discharge into Rivers.**—Though commonly in vogue in many large Indian towns this is likely to prove injurious, if the discharge takes place at a point up the stream, for the reason that people living on the banks down below will draw polluted water for their domestic purposes, which may prove exceptionally injurious in times of the year when the river flow is at its lowest.

The Rivers Pollution Prevention Act was passed in England in 1876 and in 1890, which makes it illegal to allow crude sewage to pass into rivers or streams. The sewage must

be purified before it is discharged into them. The standard of purity to be aimed at is that the effluent should not contain more than 0.15 part of albuminoid ammonia in 100,000 parts.

3. **Disposal after rendering Purification.**—Purification means the removal of the organic and oxidisable matter, and is effected in either of the three following ways, *viz.*, subsidence, straining or precipitation.

Subsidence.—In this method crude sewage is collected in large tanks made of cement or brick to the bottom of which the solid suspended matter slowly gravitates leaving a comparatively clear fluid at the top. The effluent, however, is not harmless, as it still contains large quantities of organic matter and bacteria and is still capable of undergoing decomposition and of causing a nuisance and danger to health.

Straining.—In this method crude sewage is carried over a bed of ashes or charcoal through which its liquid portion slowly percolates leaving the heavier solid matter covering the bed as a thick crust. This method does not seem to be ordinarily practicable, as it necessitates a frequent cleansing of the filtering beds to ensure its efficiency.

Precipitation.—This process consists in the addition of some chemicals, which form insoluble compounds, and these, precipitating to the bottom, carry with them suspended solid matters as well as a proportion of dissolved organic matter in the sewage. The fresh sewage is thoroughly treated with the chemical agents, and is then caught in a double row of tanks, four to six feet deep, in which its solid particles quickly settle down, while the liquid portion at their top is either discharged into a stream or river, or carried along specially constructed drains into adjoining land for purpose of irrigation or of fertility. The following are the chemical agents which are commonly employed for purifying sewage :—

a. **Lime.**—12 to 16 grains of lime are added to each gallon of sewage, when the lime combines with carbonic acid forming an insoluble carbonate of lime and also with some of

its organic bases. These and the suspended matters fall together to the bottom and form the sludge. Lime in solution is much more effective. The treatment of sewage with lime is cheap, and is especially suited for those towns where sewage contains salts of iron and mineral acids and carbonic acid as in breweries. However, the chief disadvantages are that the effluent is rendered more alkaline and more putrescible, and the sludge is also bulky and decomposable.

b. **Alum.**—Alum sulphate from 5 to 10 grains is used for each gallon of sewage. It produces a flocculent and gelatinous precipitate which entangles and carries down with it most of the particulate matters in suspension. The effluent is neutral, and is, therefore, not liable to decomposition. In Anderson's process alum in a crude form is made by acting on clay with sulphuric acid.

c. **Mixture of Lime and Alum.**—When 5 grains of lime and 5 grains of alum are mixed together for each gallon of sewage, the sulphuric acid of the alum combines with the lime, and a precipitate of alumina hydrate is formed, which carries down with it all the suspended matter and much of the organic matter. This method is more efficient than alum or lime alone.

d. **Proto-Sulphate of Iron.**—This salt added to alkaline sewage or to sewage previously treated with lime forms a flocculent precipitate of hydrate protoxide of iron, which falls to the bottom carrying with it solid organic matters. It is also a strong antiseptic and prevents the secondary decomposition of the sludge and the effluent, when added in a sufficient quantity. Ordinarily 2 to 5 grains of the salt are added per gallon of sewage.

e. **Sillar's A. B. C. Process.**—The chemicals used in this process are alumino-ferric, blood, clay and charcoal, and the process is so named from the initial letters of these substances. When they are used together, they produce a precipitate, which also causes a sedimentation of solids.

Hillé's Process.—In this process magnesium

chloride is used as a precipitating agent together with lime. Sometimes tar is also added to them.

g. **Amines' Process.**—In this process the sewage is treated with milk of lime and herring brine, when a volatile aminol is evolved. It acts as a deodorant and antiseptic, and renders the sludge inodorous.

h. **Hermite System.**—This system consists of treating sewage with electrolyzed sea water. An electric current is passed through sea water contained in a galvanized iron tank, when magnesium chloride is decomposed and forms a disinfecting solution of a strength equal to 0.75 gramme of chlorine. It is asserted that this solution decomposes at once the fæcal matter contained in the sewage and thoroughly sterilizes it, but this has not been borne out by experiments. Again, bleaching powder dissolved in water is equally efficacious and much cheaper.

i. **Webster's Process.**—In this process purification of sewage is effected by electrolysis. The sewage is electrolyzed as it is passed at a low velocity through a chamber, fitted on its interior with large iron plates. At the positive pole chlorine and oxygen are given off, and these unite and form hypochlorous acid. The acid acts upon the organic matter, and also forms hypochlorite of iron. At the negative pole ammonia, potash, soda, magnesia and other alkaline bases are set free, and these in their turn decompose the iron hypochlorite into the hydrated oxide of iron. This rises to the surface as a scum along with bubbles of air, and so purifies the sewage. The effluent is rendered pure by the disinfecting action of the chlorine and also by the precipitating action.

Owing to the nuisance arising from rapid putrefaction of sewage from its exposure in large open tanks this method of purification by chemical agents is not suited to the hot climate of India. It is also being given up in England, as the effluent is in no way free from organic matter and pathogenic bacteria, and is also harmful to fish-life owing to salts added to sewage, if directly allowed to pass into

streams ; while the sludge formed is very bulky and contains as much as 95 per cent. of water. It has, therefore, to be dried, and compressed into cakes for distribution as manure.

(4) **Disposal by Biological Treatment.**—As is well known, micro-organisms found in soils are liable to act on organic matter—animal or vegetable—and to break it up into simpler oxidisable substances which ordinarily supply nutrition to plants. This natural process of oxidation through the agency of micro-organisms may also be applied for the disposal of sewage. Two kinds of micro-organisms are ordinarily met with in sewage, known respectively as anærobic and ærobic. The former liquefies the solid organic matter and converts it largely into ammonia and ammoniacal products, while the latter effects further chemical changes resulting in the conversion of these ammoniacal substances into the simpler forms of nitrites and nitrates. It is said that through the action of a preponderating number of these organisms pathogenic germs come to be largely destroyed.

Several devices have been put forward for this particular method of biological treatment, of which the most important are—

a. The Septic Tank System.

b. The Scott-Moncrieff System.

c. The Activated Sludge System.

a. **Septic Tank System.**—This is a system advocated by Mr. Cameron, Borough Surveyor of Exeter, and adopted by Major Clemesha, I.M.S., for the use in Indian towns. This system is particularly suited to the requirements of small towns and cantonments, and it has an advantage that latrines can be constructed over septic tanks into which the excreta at once pass. These are called septic tank latrines and are usually built in jails and hospitals, where a large latrine accommodation has to be provided, and where a sufficient supply of water is available.

The system consists of a septic tank and contact beds (filtering beds).

Septic Tank.—The septic tank is an underground air-tight, rectangular tank made of brick lined with cement. Clemesha recommended that the length of the septic tank should be five or six times its width and the depth six feet, but George Bransby Williams has found that such a narrow and long septic tank is not economical, and recommends that it should usually be four times as long as it is wide, and six to eight feet deep. It may be open or closed, but in India it should be closed to suit its climatic conditions. It is provided with an inlet pipe for receiving the excreta, which opens below the water in the tank, and an outlet pipe for the discharge of the effluent, which is also situated below the surface. The sewage is first allowed to pass into a grit or detritus chamber, where pieces of stone, grit, etc., are deposited and then it drains slowly into the septic tank proper or digesting chamber as it is sometimes called, so that solid organic constituents have time to settle at its bottom, and a scum collects at the surface. The anærobic micro-organisms split up the solid organic constituents into soluble and unstable compounds and liquefy them. The black deposit of sludge which accumulates very slowly in the bottom of the tank, is largely composed of indigestible material consisting of mineral matter, cellulose, vegetable and elastic fibres, cartilage cells, etc. The amount of this deposit is very small, but as soon as it becomes eight to twelve inches in thickness, it should be removed and deposited into trenches. As a result of fermentation a scum forms on the upper surface, varying from 2 to 6 inches in thickness. The scum further undergoes digestive changes owing to the action of anærobic bacteria, and the organic matter is decomposed into water, nitrites, nitrates and gaseous products, such as carbonic acid, ammonia, marsh gas and sulphuretted hydrogen. These gases may be employed either for heating, or after carburetting for lighting purposes. The flow of sewage through the tank must be slow, so that the bacteria may have sufficient time to act on the sewage. For the proper action of the anærobic

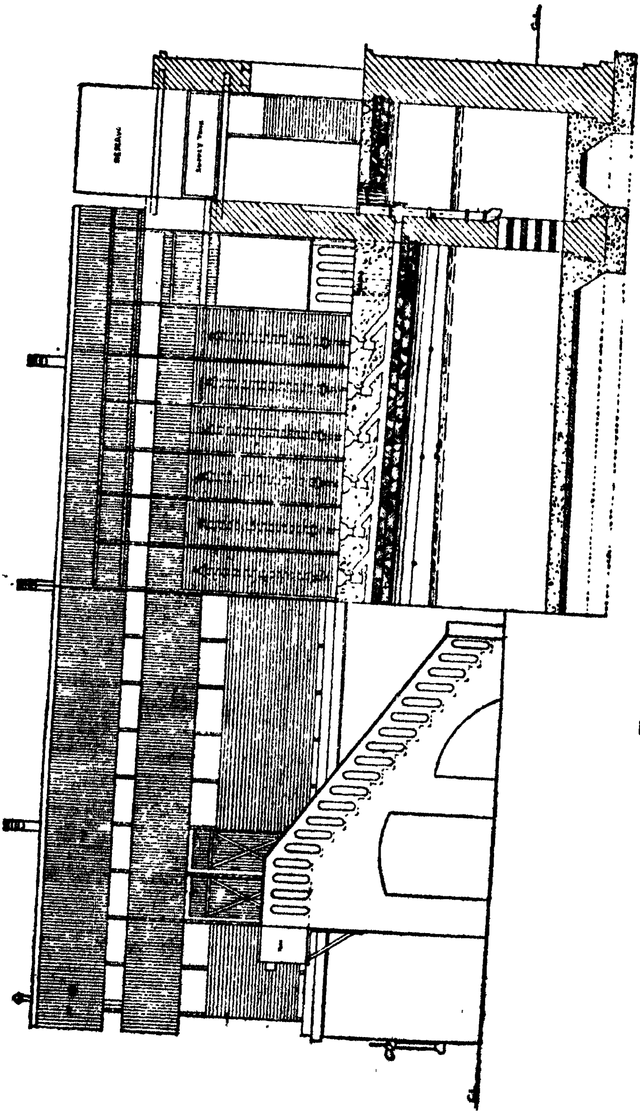

Fig. 36—Septic Tank and Latrine.
(After W. Clemesha, Sewage Disposal in the Tropics).

bacteria the sewage ought to be allowed to remain in the septic tank from 12 to 24 hours, but in India it is sufficient to keep it for 6 to 12 hours.

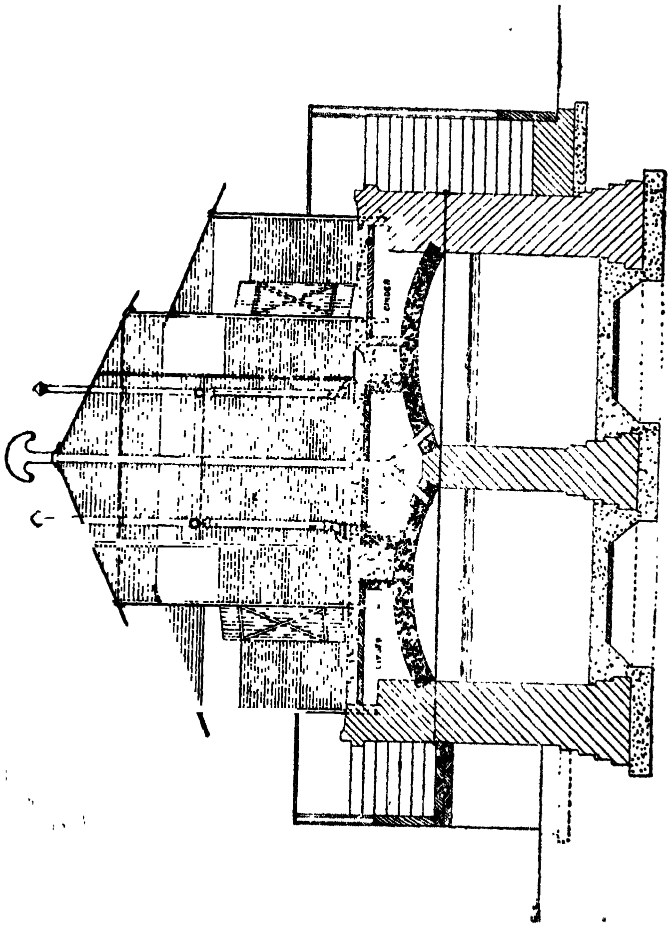

Fig 37—Cross Section of Septic Tank and Latrine.
(After W. Clemesha, Sewage Disposal in the Tropics).

Contact Beds.—The dark coloured liquefied portion of the sewage from the digesting chamber is passed out in a trough or "ærator" placed outside, from which it flows into channels, and ultimately is discharged on to filter or contact

beds. Each bed is rectangular in shape, 3 to 4 feet in depth and is either made by building artificial walls or by digging out the ground where it is of clay. The bottom is made of concrete and slopes from its centre to the sides, which are surrounded by a drain for collecting and carrying away the effluent. Upon the bottom are placed filtering materials consisting of pieces of broken stone, furnace clinkers, quartz and gravel of graded size varying from ¼ inch to 2 inches in diameter. There should be adequate arrangement for periodical removal, washing and replacement of these filtering materials.

The liquid portion of the sewage is distributed evenly over each bed by means of stoneware channels, or by fixed or revolving hollow perforated tubes known as sprinklers, so that the sewage simply trickles through the filter. In passing through the filter the organic matter contained in the fluid portion of the sewage is further broken up into ammonia, carbonic acid, sulphuretted hydrogen, water, as well as nitrites and nitrates by the action of the ærobic organisms present as a gelatinous layer on the upper portion of the filtering mediums. It is necessary that the filtering bed must be ærated. Hence the liquid should be allowed to percolate at intervals in the case of small contact beds. To obtain this rest there should be several contact beds, so that they can be used in rotation. Each small one should be made to work only 4 hours a day and should have a rest of 20 hours. In the case of large contact beds the liquid may be supplied continuously, but slowly, by means of revolving sprinklers. These beds are also called percolating continuous filters. Both the filter beds are quite effective. The area required for a population of 1,500 persons is generally half an acre.

b. **Scott-Moncrieff System.**—This is another system in which both non-ærobic and ærobic organisms play their part in purifying sewage. The sewage is first allowed to flow through a perforated grating, which forms a false bottom of a tank (cultivation tank) filled with various sizes of broken

stone, gravel, etc., and then to pass upwards slowly and continuously. In its upward passage through the filter the solid suspended matters are retained, and solid dissolved organic matters are liquefied by the action of anærobic organisms present in the sewage. The effluent escaping from the top of the tank is conducted into a series of nitrifying trays containing large pieces of coke placed one above the other. Here the ærobic organisms further act on the effluent with the result that it becomes clear, odourless and non-putrescible.

c. **Activated Sludge System.**—This method has recently been introduced, and aims at the complete purification of the sewage, so that the resulting effluent is non-putrescible and is not likely to give rise to a nuisance when discharged into the smallest water course. It depends for its action on the oxygen supplied by the air, which in the presence of organisms oxidizes the organic matter of the sewage.

The crude sewage is first passed through screens to remove large solid particles, such as stone, gravel, etc., and is then allowed to enter a specially constructed tank, known as an ærating tank. Compressed air in a finely divided condition is pumped through the sewage in this tank for about four hours in the proportion of 1.75 cubic feet per gallon of sewage, so that the bubbles of air rise to the surface causing the sewage to be thoroughly agitated. The ærobic micro-organisms increase in numbers and activity, and break up the organic matter of the sewage causing formation of the sludge which settles down to the bottom as a precipitate and a clear, non-putrescible liquid which comes over on the top. The sludge is charged with micro-organisms which are carried down with it to the bottom, and is then spoken of as "activated" or "ripened." Portions of this activated sludge can be used over and over again for the activation of fresh sewage. The remaining sludge is a valuable product as a fertilizing manure owing to the higher percentage of nitrogen content (6 %) than the sludge resulting from other methods of sewage purification.

In the earlier installations the operation was conducted on the fill and draw system, but it is now carried out on the principle of continuous flow in an æration tank without any interruption. This system has been in operation for sometime at Jamshedpur and at the Bengal Engineering College at Sibpore near Calcutta. The plant at the college is described below :—

"In this installation[1] there is a provision of dealing with the sewage of 1,200 persons together with a small amount of surface water. A daily dry weather flow of 42,000 gallons a day is provided for, nearly all of which will come down between 6 A.M. and 9 P.M. The capacity of the ærating tank is 21,000 gallons, which gives a period of somewhere about 8 hours' æration during the period of day flow.

On arrival at the outfall works the sewage is raised by a series of three air lifts and is discharged along a channel over a weir into the mixing chamber where it meets the returned sludge. The mixture of sewage and sludge is then raised by a fourth air lift, and passes through a coarse screen into the disintegrating tank. This is a circular chamber with a bottom sloping towards the centre and arranged in a series of ridges and furrows. In each furrow there is a diffuser. After the larger organic solid suspended matter has been broken up in the disintegrating tank, the sewage passes through a circular fine screen and grease chamber into the ærating tank which is arranged in three longitudinal compartments. The sewage travels along the whole length of those compartments and in the meanwhile undergoes æration. When it reaches the end of the last compartment, the sewage and sludge pass into the settling tank through a cast-iron pipe, the inlet to which is closed by a disc valve. This valve acts as a throttled outlet. The diffusers in the æration tank are arranged in longitudinal rows near the bottom of the two division walls. The air supply is through a number of air pipes. The settling tank is

1. George Bransb Williams, Sewage Disposal in India and the East, 1924, p. 173.

of a pyramidal upward flow type, 9 feet square and 13 feet 6 inches deep from top to water level, its capacity being 4,000 gallons. The effluent from the septic tank is discharged over a masonry weir to an irrigation area, where the surplus sludge will also be disposed of. The returned sludge is conveyed along a re-æration channel by gravity, and is discharged into the mixing chamber over a weir. The compressed air is delivered by blowers in duplicate, each capable of compressing 200 cubic feet of free air per minute to a pressure of $4\frac{1}{2}$ pounds, driven through belts from A.C. motors, 220 volts, 19.5 amperes, running at 750 revolutions per minute."

(5) **Disposal by Direct Land Treatment.**—In this process it is advisable to remove a large portion of the grit and suspended matter from the sewage by screening and sedimentation or by precipitation with chemicals before it is discharged on a plot of land either by intermittent downward filtration or by broad irrigation or sewage farming. The Royal Commission on the Metropolitan Sewage Discharge have defined filtration as "the concentration of sewage at short intervals, on an area of specially chosen porous ground, as small as it will absorb and cleanse it; not excluding vegetation, but making the produce of secondary importance. The intermittency of application is a *sine qua non* even in suitably constituted soils, wherever complete success is aimed at; hence the process is commonly spoken of as intermittent downward filtration."

For successful filtration the land should be porous in consistence and provided with drains of porous earthenware for subsoil drainage at a depth of six feet at distances of twenty to hundred feet from each other, the distance varying with the porosity of the soil. The surface of the land must be levelled, and must have a proper slope to allow the equal distribution of sewage over the whole area. The land should be divided into four sections, so that each section may receive the sewage for six hours and have a rest of eighteen hours. The surface of each section should be laid out in ridges and furrows, the latter allowing a free flow of the liquid sewage,

while vegetables and grass may grow on the former. The purification of sewage is both mechanical and biological, effected by filtration and nitrifying organisms present in the superficial layer of the soil.

The effluent coming out of the subsoil drains is clear and non-putrescible but not sufficiently pure to be discharged into a stream or river, the water of which is used for drinking purposes. Houston definitely points out that "the results conclusively show that the treatment of sewage on land cannot be relied on materially to modify the potentially dangerous qualities of crude sewage. The actual number of objectionable microbes persisting in the effluents is too great to allow of much stress being laid on the great percentage reduction effected in the total number of microbes by the land treatment, or to insure any certainty that effluents from land processes are relatively safe." Hence it is advisable to treat the effluent with a disinfectant, such as chlorine or a hypochlorite solution, 1 to 2 per cent. before it is allowed to run into a stream or watercourse.

An acre of land is generally required for treating the sewage of 1,000 persons, but it will suffice for 2,000 to 5,000 persons if the sewage is previously treated with chemicals, though such sewage is deprived of much of its manurial value.

Broad irrigation is defined by the Royal Commission on Metropolitan Sewage Discharge as "the distribution of sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied."

For purposes of broad irrigation or sewage farming a considerably large plot of land is brought under operation. Its consistence should be porous, and wherever clayey or hard, it should be made thoroughly loose and porous by being dug up and mixed with ashes, sand or lime. The fall should be from the town to the land chosen, so that the sewage may flow to it by gravitation. An underground

drainage should be arranged for it, so that the effluent or nitrate may be carried away to the nearest water course if necessary. The land is laid out in ridges and furrows, and the sewage is discharged on it in as fresh a condition as possible, after coarse material is removed by screening or sedimentation. To ensure success, however, the sewage should not be allowed to pass continuously but intermittently to permit æration of

Fig. 38—Ridges and Furrows.

the soil. The Ministry of Health, England, has laid down that an acre of land is necessary for the treatment of sewage of 300 persons, but it has been found by experience that an acre of land is sufficient for a population of 1,000 persons. Grass, sugarcane, and vegetables, such as cabbages, etc., grow abundantly on such sewage farms. The disadvantages of such a method are that it may encourage the breeding of mosquitoes, and may pollute wells, if situated in the neighbourhood.

Standard of Purity of Sewage Effluents.—From the reports of the Royal Commission on Sewage it has been made clear that several methods used for purifying sewage break up the complex organic bodies into simpler bodies, and may produce a non-putrescible effluent but are incapable of rendering it sterile or anything approaching it. Pathogenic micro-organisms have been found to persist in the effluents though their number might have been reduced. As far as these microbes are concerned, the effluent must be regarded as dangerous to health as crude sewage. Hence it is dangerous to allow the effluent to be discharged into streams or rivers which are used as a water supply for drinking purposes, or into water courses where water cress is grown or into estuaries where oysters and other fish are laid.

It is impossible to lay down any standard of bacteriological purity for sewage effluents to be discharged into streams or rivers, as the conditions vary at different places. However, for general guidance the Royal Commission on Sewage Disposal laid down in 1912 the following standard of purity for a sewage effluent which can be discharged into rivers and streams without detriment to fish life or to the health of the populace :—

1. The effluent must be clear, bright and free from deposit or fæcal odour.

2. The effluent must not contain more than three parts of suspended matter per 100,000.

3. The effluent must not take up more than 2 parts of dissolved oxygen per 10,000 kept at a uniform temperature of 65° F. (18.3° C.) for five days.

In addition to the above the following standards have to be observed :—

4. The effluent must not contain more than 0.1 part of organic ammonia per 100,000.

5. The effluent must not undergo further decomposition after it has been incubated at a temperature of 80° F. in a closed vessel for a week.

CHAPTER XIV.

PERSONAL HYGIENE.

PERSONAL Hygiene relates to individual conduct towards the maintenance of physical health and freedom from disease. It should be based on a due observance of certain elementary principles of sanitation with reference to personal habits and cleanliness, as also to the articles of clothing, the amount of exercise and the hours of sleep.

HABITS.

The habits should be regular and healthy as regards the hours of meals, the evacuation of bowels, the professional work, and the use of restorative drugs. Meals should be taken after due intervals, at fixed hours and in quantities compatible with one's work. The proverbial thirty-two bites for every morsel of food should never be forgotten. The bolting of unchewed morsels is most objectionable as it is difficult for the stomach to digest them. Excessive ingestion and irregularity of meals usually bring about symptoms of indigestion. Similarly inattention to a regular easing of the bowels is likely to bring about unhealthy consequences, such as constipation, toxæmia, headache and a general sense of malaise. Intellectual work, especially of the kind necessitating prolonged application at desk, cannot be performed efficiently after heavy meals and without being varied with short periods of rest. It may be observed that Indian students generally are scarcely cognisant of the importance of these essentials pertaining to their work. It is, therefore, not infrequent to come across most pitiable instances of physical ruin brought about solely through a lamentable ignorance of such commonplace hygienic facts.

As far as possible no other fluid except water should be taken. Water, if it is pure, may be taken with impunity by

any person of any age. It should be remembered that infants like adults do suffer from thirst and should, therefore, be given sips of water to drink.

Water should not be taken at meals, but should be taken freely in the intervals between meals. It is best to take a glass of cold water early in the morning on rising and at night before going to bed.

Alcohol or other fermented liquors must be avoided. In a tropical country like India they are both unnecessary and harmful. Old persons may require alcohol to stimulate them, just as an old tired horse requires flogging, but young persons have no excuse to use it.

Tobacco is the drug which is habitually used by the large majority of Indians as a restorative. The principal forms in use are the leaves for chewing, powdered leaves for inhaling as snuff, and the prepared tobacco for smoking. Its use particularly as a smoke is indiscriminate, even though it harms digestion, is likely to bring about a sense of depression and may also injuriously affect the eyesight. It is extensively used by the people of India, and still cases showing injurious consequences are seldom met with.

Nevertheless, its use by young persons under twenty years of age should always be discountenanced, and older persons should be advised to use it regularly and in moderate quantities only. The habits of chewing it and of using it as snuff are, to say the least, dirty, while the former usually proves injurious to a healthy preservation of teeth.

Sleep.—Sleep at regular hours is necessary to repair the waste of the brain and the nervous system incurred by the body during the period of activity. It is in fact a time of repose for all the organs. The amount of sleep required by the same individual in different periods of life, seems to be in inverse proportion to the intensity of consciousness. Consciousness is not intense at the two extremes of life, and hence in infancy and in old age much sleep is required, but in adult life consciousness is more intense and so less sleep is necessary.

Ordinarily seven hours' sleep is enough for grown-up persons, but it is impossible to fix the exact period of time for sleep for every individual as it is difficult to estimate the amount of food required by different people. Night is the best time for sleep owing to the prevailing quiet, as the presence of external stimuli to the brain causes insomnia. The bed-room should be well-ventilated and the bed should be firm and elastic. The bedding should be kept neat and clean, and should be frequently exposed to the sun. It is injurious to sleep on the floor. Besides the danger of being bitten by scorpions, snakes and other poisonous insects, there is always a danger of contracting rheumatism, diarrhœa, dysentery, fever, pleurisy and other lung affections owing to the dampness of the soil and the inhalation of foul air emanating from it. It is also advisable to have a sleeping-room on the upper floor if the house has more than one storey. The head should not be covered up during sleep, lest the foul gases exhaled might be inhaled. Two persons should not sleep in the same bed, as they will inhale each other's breath. The trunk should always be well-covered to avoid catching chill, and the bed should never be kept in the direct draught of air, though the windows of the room should be kept open at night for thorough ventilation. There should be an interval of at least three hours between the last meal and the hour of bed, for a heavy meal taken just before going to sleep causes insomnia. Lastly, the popular adage, "Early to bed and early to rise makes a man healthy, wealthy and wise" should always be borne in mind.

CLEANLINESS.

Cleanliness is very essential for the upkeep of our health and for the growth of our body. There is an old proverb that "virtue is its own reward". One should, however, remember that cleanliness has a much greater reward in the way of health, happiness and long life. Attention should always be paid to the cleanliness of the skin, teeth, hair and clothes. The skin should be kept clean and free from dirt.

In India owing to excessive perspiration it becomes necessary to keep the pores of the skin free from dirt, so that the sweat glands may do their work properly; for if they are clogged, and if the dead scales from the skin are not removed, its action will fail, and to remove waste products more extra work will be thrown on other organs of the body, *viz.*, the lungs and kidneys. Water is the great remedy to clean the skin, but soap should always be used to remove grease and dirt. Care should be taken that good soft soap is used, as hard coarse soaps are apt to cause cracking and chapping of the skin. Especially where the skin is tender, as in the case of babies and very young infants, soft soap containing more fat is always to be preferred.

A daily bath should always be taken early in the morning or in the middle of the day before, but not immediately after, a meal or after exhaustion by fatigue. Young, healthy people should always use cold water for a bath as it is vigorating and refreshing, but if one feels chilly after the bath, one should use tepid or warm water. Children and old people also should use tepid or warm water, as they are liable to get chill with cold water. The temperature of cold water should vary from 55 deg. to 65 deg. F., and that of warm water from 94 deg. to 104 deg. F. Even those who take a cold bath daily should occasionally take a hot bath with a temperature varying from 104 deg. to 110 deg. F., as hot water has a more solvent action on dirt and oily matter than cold or tepid water.

The ordinary way of Indian bathing of pouring a few *lotas* of water over the head and back, is not at all good. Soft soap should first be applied to the skin, and then there should be vigorous rubbing over the whole body, and lastly, it should be washed with sufficient water. During sickness when a bath cannot be taken, it is always healthy to rub the body with a towel wrung out in tepid or warm water. Massage or shampooing of the muscles is a very good practice specially when the muscles are flabby and in the case of people who have a poor physique.

Hair.—The hair of the head should be kept thoroughly clean, and should always be combed and dressed. If the hair is not properly looked after, several troublesome diseases, such as ringworm and dandruff may arise, while frequently lice also make their appearance. It is necessary to wash the hair once a week with soap and water or with soap-nuts or myrobalans soaked in water. Oil should not be used too frequently, as is the custom among Indians, because it mats the hair together and harbours dirt. Nature has provided the scalp with oil or grease, which keeps the hair soft and pliant. If oil has to be used, it should only be used once a week, after washing the hair with soap, to replace the natural grease.

Teeth.—It is essential that the teeth should be thoroughly and regularly cleaned, for good digestion depends upon the thorough mastication of food, which cannot be done without strong teeth. They should be cleaned once in the morning after getting up, and a second time before going to bed. The Hindu custom of using a green *neem* or *babul* stick for cleaning teeth is very good from a hygienic point of view, but it is really a matter for regret that this stick is being replaced by tooth-brushes, which are not very sanitary, as there is always a difficulty in keeping them clean and the same brush is used for a long time If the tooth-brush has to be used at all, it should be kept dry in a glass bottle when not in use, and should be kept in boiling water for some time after use. It should also be frequently changed. Tooth-powder is generally used with the brush. Several varieties are being sold in the market, but nothing can be better than charcoal and common salt powdered and mixed together or powdered chalk and borax. After the brushing is over, the tongue should be cleaned by a tongue cleaner, and the mouth should be rinsed out with warm water containing a little borax. The teeth should be well cleansed after every meal; food particles are liable to remain lodged between them and so they should be removed by a tooth-pick or by a piece of string passed between two teeth. If there are cavities in

the teeth, they should be filled up, but if they are very carious, they should at once be removed lest they may spread decay to other teeth. When the teeth fall away, artificial teeth should be used, if one can afford them.

Nails.—The hands and nails should be kept scrupulously clean specially as most of the Indians eat with their hands, and do not use spoon and fork. This is particularly necessary for those who nurse the sick. The poison and the dirt lodge under the nails and so they should be pared down with a pair of scissors and a stiff nail-brush should be used to cleanse them. Cuts and scratches received on the hands during work are likely to get infected, if they are not kept clean. The hands should always be washed with soap and water before and after meals. The fingers should never be introduced into the mouth and the nose. Some disinfecting lotion must be used for washing the hands while attending on persons suffering from infectious diseases.

Feet.—The feet should be kept clean by frequently washing them with hot water and soap. In the summer they become offensive owing to free perspiration. The perspiration, if not removed by properly washing the feet, dries up on the surface, undergoes fermentation, causes irritation and skin diseases, such as impetigo and eczema. The toe-nails should not be allowed to grow too long, as they would crack and break off leaving ragged ends. They should, therefore, be kept fairly short by cutting them down. They should always be cut straight across, and not rounded off at the corners. If they are cut away at the corners, they tend to grow at these places into the skin by pressure of the narrow-toed boots, and to produce what is known as an ingrowing toe-nail, which is most painful.

EXERCISE.

Exercise is necessary for the growth and development of the body and the perfect maintenance of health. Bodily strength is essential for success in life, as much in the case of

an individual as in the case of a nation. A strong man can work in life with great vigour, and can stand the worries better than another who is weak in constitution, and a weak nation is always ruled by a strong one. The British soldier is so much known for his daring and power to sustain hardships, simply bacause he has a love for sports and takes delight in manly games. Even on the battle-field he does not forget his football, if he gets some respite.

Without exercise the muscles become pale and flabby, and begin to waste. The appetite is lost, and indigestion and constipation are the result. The man who does not take exercise feels greatly depressed, cannot take interest in anything in life and becomes a prey to the attacks of diseases, while by exercise the voluntary muscles are brought into active play and grow harder and firmer. The frequency and force of the heart's action are increased and the blood circulates more freely through the whole body. The number of respirations is increased. There is a considerable increase in the amount of oxygen inhaled and carbon dioxide and watery vapour exhaled. Hence the oxygenation of the blood is very much accelerated. There is a marked increase of perspiration owing to the increased action of the skin, and consequently the quantity of urine diminishes, though the amount of urea and uric acid remains unaltered. The appetite is improved and the action of the bowels is stimulated. The mind is also refreshed, and the powers of observation, precision and tolerance are developed.

Exercise should be taken in the open air, and this is much more essential to brain-workers, such as lawyers, doctors, clerks, teachers and students, who have to work all the day in closed buildings. It should also be such as would give recreation and relaxation to the brain. There are various kinds of exercise, such as gymnastics, wrestling, dumb-bells, games of football, hockey, tennis, cricket, cycling, riding, walking, running and gardening. But walking is the best of all, as by it all the muscles of the body are brought into play,

and it does not require any special apparatus or any expenditure of money. An adult who does not take any other exercise should walk at least five miles morning and evening. It should be impressed on the mind of parents that exercise is equally necessary for young girls, who ought to devote some of their time to outdoor games. As the mothers of the future race, they ought to be strong, vigorous and healthy. It is a healthy sign that efforts are being made to revive the old forgotten indigenous games, such as *kabaddi*, *gilli-danda*, etc., in villages.

Whatever exercise is taken it should be in moderation, for severe and prolonged exercise is harmful to health. It causes breathlessness, palpitation and hypertrophy of the left ventricle and renders the pulse small, frequent and irregular. The voluntary muscles become exhausted owing to overwork, suffer in nutrition and naturally begin to waste. After exercise the body should be well washed with soap and water, and should be carefully rubbed dry with a towel, so that the skin should not remain damp and dirty owing to the increased action of the sweat glands. The time of exercise should be early morning or evening. One should not eat too soon before or after exercise.

To calculate the amount of exercise needed for an individual it is necessary to remember that a healthy individual of average height and weight can perform in a day ordinary physical work equivalent to 300 foot-tons without losing weight or suffering any inconvenience. A very hard day's work equivalent to 500 foot-tons cannot be performed for long without losing muscular vigour and weight, even if the diet was considerably increased. According to Hangton the work performed by an individual walking on a level road is equivalent to raising his body plus the kit he carried to a certain fraction of the distance walked. This fraction, which is known as the *Co-efficient of traction*, varies according to the rate of speed in walking. Thus, for a speed of 2, 3, 4 and 5 miles an hour, it is 1/26, 1/20, 1/16 and 1/14 respectively.

The formula for estimating the work done in walking is $\frac{W \times W^1 \times D}{2,240} \times C$ = foot-tons, where W = weight of the body in pounds, W^1 = weight carried in pounds, D = distance walked in feet, C = co-efficient of traction, and 2,240 = number of pounds in a ton.

CLOTHING.

Clothing is used to maintain the normal heat of the body and to protect it from cold, heat, rain, wind and external injuries; the purposes of decency and decoration are also served by it.

The materials used for clothing are derived from animal and vegetable kingdoms. Those derived from animals are wool, feathers, fur, leather and silk, while cotton, linen, and india-rubber are derived from vegetables.

Wool.—Wool is a bad conductor of heat and a great absorbent of moisture. Being a bad conductor of heat, wool is warm and is worn in winter, as it does not allow the body heat to escape to the outer air, which is cooler than our bodies. The natural tendency of heat is to run from a higher to a lower level; hence if we do not wear woollen garments, our body will give up its heat to the surrounding cooler air and we shall feel cold. Similarly, in summer it helps us in preventing the sun's heat from being conducted to our body, if it is worn next to the skin. Owing to its property of absorbing moisture, woollen garments should be worn immediately after hard exercise, when the body has been perspiring, to avoid chills caused by lowering of the temperature owing to the evaporation of perspiration. The disadvantage of wool is that its fibres shrink, and become harder on washing, and thus they lose their hygroscopic power. The woollen cloth should, therefore, be first soaked in water, before it is made into a garment, and it should then be washed in soft cold or tepid water with mild soap, and should be dried without wringing out. Woollen garments being rough may cause skin affections when worn next to the skin, but they can be tolerated by habit. Flannels, blankets,

shawls, worsteds, merino, cashmere, alpacca, etc., are manufactured from wool.

Furs.—These are very warm and afford protection to the body against cold and wind. They are very much used by European ladies as personal adornment. Fur is also used to make felt.

Feathers.—These are used by rich people for stuffing quilts and pillows, and by ladies as decorations to their hats.

Leather.—This is used as a clothing in very cold countries to protect against cold, bleak winds and rain ; but it cannot be used for underclothing, as it prevents the ventilation of the air next the skin owing to its being non-porous.

Silk.—Silk is a bad conductor of heat and absorbent of moisture, though it is less so than wool. It is a non-conductor of electricity. Owing to its soft and fine texture it would be a useful article for underwear but for its cost. It does not shrink on washing so much as wool, and does not irritate the skin. Satin, plushes, velvets, ribbons, crape, etc., are manufactured from silk.

Cotton.—This is cheap and durable, and does not shrink on washing. It rapidly conducts away heat and does not absorb moisture ; therefore it is not a good material for underclothing, for, in the case of perspiration, it becomes wet and causes chill. In what is called "cellular" cotton cloth, there are large interspaces between the fibres, which hold air ; and air being a bad conductor of heat, this cloth is warmer than ordinary cotton cloth. Various fabrics of cloth are manufactured from cotton, *viz.*, jean, calico, twill, etc. It is mixed with wool to form merino, and is mixed with silk to make the cheaper kinds of silk goods.

Linen.—Linen is manufactured from the flax fibres. It is, in no way, superior to cotton, for like it, it is a good conductor of heat and a bad absorbent of moisture. On account of its smoothness and gloss it is used for making cuffs, collars and shirt fronts. Bed sheets made of linen, are very cool and comfortable.

India-rubber.—This is elastic and impermeable to water, and hence is largely used in making water-proof coats, that are worn during the rainy season.

General Remarks on Clothing.—Clothes should be made of such materials as would preserve the body heat in winter as well as in summer, and should be so designed as would maintain the uniform temperature of the whole body. They should be white or grey in colour to protect the body from the direct rays of the sun. Black and blue colours absorb heat very readily, and so the outer garments made from these colours should never be worn in the summer when going out, but they can be worn under the shade as the sun's rays have no effect on them under shade.

Clothes should always be adapted to the different seasons of the year. They should be light and loose so as not to interfere with the functions of any of the organs. They should not press so tightly at the neck, chest, belly or waist as to impede the circulation of the blood or to change the natural contour of the parts, but should allow free movement to the muscles. They should be porous, and should not interfere with the normal functions of the skin. People should be very careful in using coloured clothes, which are generally made with aniline dyes containing arsenic. They irritate the skin, cause skin affections, such as eczema, and sometimes poison the system. It is much better, therefore, to avoid gaudy colours.

The same clothes should not be used for the day and the night. Even the poorest man should have at least two sets of garments. The clothes worn during day should not be kept in the sleeping room at night. Clothes, especially those worn next to the skin, should always be kept clean and neat, and should be frequently changed. Dirty underwears stink horribly, and are infested sometimes by pediculi, which set up irritation to the skin, and cause great inconvenience.

In a tropical country like India a suitable head dress should always be worn while going out, to avoid the effects

of the sun's rays. The turban is very good for such purposes but, if a hat has to be used, it should be so made as to cover the temples and the nape of the neck in order to protect the medulla oblongata from the direct action of the sun's rays. It does not matter much for women as the long hair that they wear is quite enough to save them from sunstroke.

Boots and Shoes.—Except during rains shoes are preferable to boots, as they allow the ankle more room to move. Whichever are used, they should fit the foot accurately, but at the same time all the toes should have free movement, the big toe should be in a straight line with the instep and the sole should be broader than the foot, and should be soft and pliant, though strong and durable. The heel should be broad and low. High heels cause a great inconvenience to the wearer in walking even a little distance. Most of the common deformities of the feet are due to badly fitting boots.

Children should be allowed to play about in the house without any shoes or boots, so that their feet may fully develop without any deformities or without any corns or bunions caused by badly fitting shoes. They are also better able to stand cold if properly nourished.

If socks or stockings are used, they should be made of wool or merino—a mixture of wool and cotton. They should not be fixed by garters, but suspended by elastic suspenders. They should properly fit the feet and not form any folds or creases.

CHAPTER XV.

INFECTION, IMMUNITY AND PREVENTION.

INFECTION.

It has been proved beyond doubt that there are several diseases, such as typhoid, cholera, syphilis, small-pox, malaria plague, tuberculosis, anthrax, rabies, glanders, malta fever parasitic diseases, etc., which are communicable between men and men, and between men and animals. This communicability of diseases is based on the "germ theory of disease," which teaches us that the infection or poison in each case is due to the living micro-organisms which are capable of independent life both within and without the animal body. These micro-organisms, when they enter the human system, are capable of growth and multiplication and generate "toxins" which produce special symptoms peculiar to each disease. In some diseases such as diphtheria and tetanus they produce toxins at the seat of infection which are absorbed into the system, while in other cases, such as relapsing fever and anthrax, the micro-organisms invade the whole system, and multiply enormously in the circulatory system as well as in the internal organs. These poisons are then given off from the body along with the excretions, and are conveyed directly from the sick to the healthy.

Koch has laid down certain phenomena by the observation of which it can be proved that a particular micro-organism is the cause of a particular disease. These are as follows :—

(1) The micro-organism must be found in the blood, lymph or diseased tissues of man or animal suffering from or dead of the disease.

(2) This micro-organism must be isolated and cultivated in suitable media outside the animal body for any required number of successive generations.

(3) A pure cultivation thus obtained, must, when introduced into the body of a healthy susceptible animal, produce the same disease.

(4) In the blood or tissues of the inoculated animal the same micro-organism must again be found.

Micro-organisms.—These micro-organisms are very minute organisms belonging to the lowest form of the animal and vegetable kingdoms. They are invisible to the naked eye, can be seen only under the highest power of a microscope and vary in length or breadth from 1/5000 inch to 1/500 inch. They are widely distributed in nature. They are met with in the atmosphere of the mountains, cities, as well as in that of the houses. They are present in water, food as also in the upper layers of the soil. They also occur on the surface of the bodies and in the alimentary tract of men and animals. During the period of infection they live in the tissues and juices of men and animals.

These micro-organisms are divided into parasites and saprophytes. Parasites are those micro-organisms which live upon, and obtain their nutrition from, the living plant or animal. They mostly produce diseases, and are, therefore, called pathogenic organisms. They, as a rule, grow at the body heat, and resist cold better than heat. They are practically few in number as compared with saprophytes, which live only upon dead or decaying tissues of plants or animals. Saprophytes are non-pathogenic, as they do not cause any disease, but are useful in the economy of nature. They rapidly destroy dead plants and animals by breaking up their complex organised tissues into simpler, inorganic compounds. They render the water of rivers and streams free from sewage pollutions, and assist the process of fertilization of the soil. They are also helpful in various manufacturing processes, such as the manufacture of cheese, alcohol, etc. They generally grow at the room temperature, *viz.*, 20° C. They are arrested in their growth at a temperature of 45° C., and are destroyed at a temperature of 60° C.

Micro-organisms which are strictly parasitic are known as obligate parasites, and those micro-organisms which are strictly saprophytic are called obligate saprophytes. Parasites are called facultative saprophytes, when they so adapt themselves as to be able to grow on dead material. Similarly saprophytes are called facultative parasites, when they can grow on the living tissues of animals or plants.

Micro-organisms belonging to the lowest animal kingdom are known as protozoa, such as the parasites of malaria. Those belonging to the lowest vegetable kingdom are called bacteria, and consist of a delicate cell-wall with protoplasm but without chlorophyll or green colouring matter. They require for their growth air, moisture and warmth, and are called ærobes. Some of them can live without air, and are then known as anærobes.

Bacteria are known by different names according to the forms which they adopt. Thus those which are round or oval in form are called micrococci, while those having rod-shaped forms are called bacilli, and those having short curved rods or comma-shaped forms are known as vibriones. Bacteria which have spiral or twisted forms are called spirilla. Those which have slender, wavy, filamentous forms are named spirochæta. Some of these microbes are capable of moving about owing to the flagella or lashing tails provided at their extremities, while others are incapable of these movements for want of such appendages.

These organisms multiply by fission or division, or by the formation of spores or eggs.

The causation and spread of the infectious diseases can be compared to the sowing of a yeast plant in a saccharine solution. This plant sets up fermentation on being placed into a sugar solution by which sugar is split up into carbon dioxide and alcohol, and the plant which is only a vegetable cell grows and multiplies. Similarly a micro organism of an infectious disease, when it gains an entrance into

the human system, acts on the body by producing symptoms. At the same time it grows and multiplies, and the increased numbers are ever ready in their turn to infect other human beings, whenever they get an opportunity to enter their system. These organisms take up some time in growing and multiplying within the body and exhibiting symptoms by generating poisons, after they have attacked the human body ; and this interval between the infection and the appearance of the characteristic symptoms is known as the period of **incubation** which is always different in different diseases. The full period of development of these micro-organisms represents the type and the course of the disease ; recovery means their decline and ultimate destruction, while death of the patient is the result of their toxicity or the lesions which they produce. It is necessary to know the period of incubation and the duration of the infectious diseases, for during those periods the sick individual is a probable source of danger to healthy persons.

Disease Carriers.—Moreover, there are persons who harbour a pathogenic micro-organism without manifesting any signs or symptoms of the disease, but who are still able to infect other individuals. Such persons are called "carriers." They are of three kinds : acute, chronic and temporary. Acute carriers are those who discharge micro-organisms a few weeks (8 or 10 weeks) after convalescence. They are also known as convalescent carriers. Chronic carriers are those who go on harbouring the micro-organisms for a very long time. Temporary carriers are those who have never suffered from an infectious disease, but still harbour and discharge the micro-organisms for a short time only. Thus persons may have typhoid bacilli, cholera vibrio or hook-worms in their intestinal tract or may carry diphtheria bacilli or other micro-organisms in their nose and throat, and yet may be in perfect health.

Modes of Infection.—Infectious diseases are carried from man to man directly by actual contact as in kissing or

through soiled hands, infected towels, cups, spoons, or food and many other articles which may have been used by sick persons. It should, however, be borne in mind that in all these cases the organism must enter the system. The mere touch or contact is not enough to bring about the production of the so-called contagious disease. In some cases the poison or virus is transferred indirectly through contaminated water, food, soil or air, while in other cases there is an intermediary host which carries infection from one individual to another. The intermediary hosts are, as a rule, insects and the chief insects concerned in the propagation of diseases are mosquitoes, flies, fleas, bugs, lice and ticks, and such diseases are called insect-borne diseases. These insects convey infection in several ways. The wings, legs, mouth parts and outer surface of the body may be smeared with the virus which is then transferred to the food and water used by men when these insects sit upon those articles; or the virus may remain attached to the proboscis of a biting insect and may be transferred to man through circulation when it bites him. In some cases the micro-organisms are taken in the digestive tubes, as in the case of fleas which carry plague bacilli in their intestinal tract, where they grow and multiply without affecting the insects. The germs are then introduced through salivary glands directly into the wounds caused by the bites of these insects, or are deposited through their dejecta on the skin near their bites and enter the system when the skin is scratched owing to irritation caused by the bite. In some cases the germs may be deposited on food or other articles, which become contaminated and then infect susceptible persons using them.

Classification of Infectious Diseases.—The actual classification of infectious diseases is difficult but, according to the vehicles through which they are conveyed, they may be classified as follows :—

1. **Air-borne Diseases.**—These are carried through the agency of air, and are small-pox, chicken-pox, measles,

whooping cough, diphtheria, influenza, mumps, scarlet fever, pneumonia, plague pneumonia, pulmonary tuberculosis, etc.

2. **Water borne Diseases.**—These are carried through polluted water, and have been discussed elsewhere.

3. **Milk-borne and Food-borne Diseases.**—These have also been described.

4. **Insect-borne Diseases.**—These are the diseases which are carried by both biting and non-biting insects. The examples are malaria, plague, typhus fever, relapsing fever, sleeping sickness, yellow-fever, filariasis, Weil's disease, sandfly fever, cholera, dysentery, tuberculosis, etc.

Infectious diseases are also classified as (*a*) epidemic, (*b*) endemic, (*c*) sporadic, and (*d*) pandemic, according to the nature of their occurrence.

(*a*) **Epidemic.**—Epidemic diseases are those which spread rapidly in a community, and attack a large number of persons at the same time from a common source of origin. In the case of these diseases the poison is imported from outside.

(*b*) **Endemic.**—Endemic diseases are those which are always present to a greater or less extent in a particular locality or district, *e.g.*, cholera in lower Bengal. These diseases are generally due to faults in local sanitary conditions, and are apt to flare up and become epidemic.

(*c*) **Sporadic.**—Sporadic diseases are those in which a few scattered cases occur in a locality now and then.

(*d*) **Pandemic.**—Pandemic diseases are those which spread in an epidemic form, and extend at the same time over a large area of the world. The best example of a pandemic disease is influenza.

IMMUNITY.

Disease germs are present in the air, in water and in our food. Hence we are ordinarily exposed at all times to the sources of infection, and yet we notice that comparatively

few of us suffer from an infectious disease, and that many are saved from its attack. This is due to their insusceptibility or immunity to that disease. This immunity, according to Metchnikoff, is defined as a group of phenomena in virtue of which, certain living organisms possess the power of resisting attacks of disease-producing micro-organisms. It may be natural or acquired. Natural immunity is due to some inherent power of the body tissues by which the individual is able to successfully withstand attacks of an infectious disease. This power is present in men as well as in animals. This immunity is not absolute, but only relative ; for an individual who is immune to a particular disease may become susceptible to it under conditions which may help to lower the general vitality of the body, such as fatigue, starvation, indiscreet living, exposure, vitiated air and unhygienic surroundings.

Immunity is said to be acquired, when it is induced by recovery from a previous attack of certain infectious diseases, such as measles, small-pox, plague, whooping cough, mumps, chicken-pox, yellow fever, typhus fever, cerebro-spinal fever, scarlet fever, typhoid fever, infantile paralysis, etc. Immunity conferred by an attack of such a disease is due to the development of certain protective substances in the blood during the attack, or due to the preparedness of the body cells to resist successfully the subsequent attacks of the disease. Immunity thus conferred is, however, rarely if ever absolute, inasmuch as secondary attacks in the life-time of an individual are not uncommon.

Acquired immunity is also obtained by the production in the blood of antibodies or substances antagonistic to bacteria or their toxins by the introduction of the bacteria or their products into the system. Immunity thus acquired is known as artificial immunity, which may be active or passive. Active immunity may be produced by—

(1) Injection into the blood or tissues of living virulent specific organisms in small, non-fatal doses. This method is fraught with danger, as the attack thus induced is as severe

as the disease contracted naturally. This was practised as a preventive of small-pox before vaccination had been introduced.

(2) Injection into the system of living cultures of specific organisms in an attenuated condition. Attenuation may be effected (*a*) by growing the cultures at a higher temperature as in the case of anthrax bacilli, (*b*) by passing the organisms through insusceptible animals, as in calf lymph vaccination for small-pox, (*c*) by cultivating organisms outside the body, as in chicken cholera, (*d*) by adding weak antiseptics to the media in which the cultures are grown, or (*e*) by drying the virus in air, as in rabies.

(3) Injection of dead cultures as used in Haffkine's preventive inoculation against plague.

(4) Injection of the extracellular toxins of the organism as used in preparing curative sera to immunize lower animals against diphtheria and tetanus.

Passive immunity is conferred on the body by the injection of anti-toxic or anti-microbic sera derived from an animal, usually a horse, that has already acquired artificially an active immunity against the disease in question. It is called passive, because the individual does not take any part in the production of immunity. Thus the injection of some anti-toxic serum from a horse rendered immune to diphtheria into the body of a child produces passive immunity in that child. This sort of immunity does not, as a rule, last long.

PREVENTION.

To suppress successfully the outbreak of any epidemic infectious disease it is necessary to acquire knowledge of the modes of transference and of the life history of any insect which may be an intermediary host in conveying the disease from man to man or from animal to man. The principal measures to be adopted to check the spread of infection of an epidemic are : (1) Notification, (2) Isolation, (3) Quarantine, (4) Education and (5) Disinfection.

1. NOTIFICATION.

In order to adopt prompt preventive measures against an infectious disease, the health officer of a municipality or the sanitary authority should immediately be informed of the occurrerce of such a disease with full particulars by the medical practitioner treating him, or by one of the relatives of the patient in the absence of a medical man. The health officer should be entrusted with full powers to take such steps as may be necessary to prevent the outbreak of such diseases. In England an Act for compulsory notification of dangerous infectious diseases to the sanitary authorities was passed in 1889 making it compulsory for every medical practitioner, under a penalty, to report a case of an infectious disease as soon as he has seen one. The advantages conferred by such notification are as follows :—

(1) Early information of all cases of a notifiable disease and therefore an accurate knowledge of the prevalence and the distribution of the disease in a district.

(2) Opportunity afforded of investigating into the probable cause of infection as to whether it is a local case or imported from some other place, whether it is connected in any way with bad water-supply or with insanitary surroundings of the premises, or whether it is conveyed by milk or other articles of food, etc. The causes of the outbreak can be detected only by thus comparing the data furnished by such enquiries, and proper measures can be adopted to check it by having recourse to isolation, disinfection, etc.

It is not possible to introduce this Act in India at present owing to want of education among the people and owing to the unwillingness of the people to consult qualified medical men for the treatment of infectious diseases, as most of the people imagine the occurrence of such diseases as being due to the visitation of a deity. Much can be done, however, in this matter by taking in confidence the public and the Vaids and Hakims who form a large majority of the medical advisers

to the people. Moreover in municipal towns of the United Provinces of Agra and Oudh, according to the orders of the Local Government passed in conformity with the United Provinces Municipal Act of 1916, a medical practitioner is bound to notify such infectious diseases as cholera, plague, small-pox, diphtheria, measles and scarlet fever to the health officer or any other officer appointed by the Municipal Board for the purpose. For non-compliance with this rule he is liable to a fine up to Rs. 50. The householder is also responsible under a penalty to report such a case at once, if a medical practitioner is not called in for treatment.

2. ISOLATION.

As soon as information is received about an infectious case, the patient should be isolated in a suitable hospital constructed for the purpose, though the patient should be given a choice of remaining under the treatment of his own medical attendant. The patient should not be removed in public conveyances which cannot be thoroughly disinfected, and which would thus become a source of transmitting infection. Besides, public conveyances, such as "ekkas," etc., are not convenient for patients to be carried. It is, therefore, best to carry patients in ambulances with 2 rubber-tyred wheels usually driven by men or in motor ambulances. Ambulances should always be kept ready for the purpose at police stations, municipal offices and hospitals in the town. They should be provided with an awning, and should be disinfected after use.

Owing to proper nursing, proper care about food, etc., and better sanitary arrangements in isolation hospitals, there are always better prospects of recovery there, than when the patient is being treated in his own house. Besides, the other inmates of the house and the community at large are protected from the disease by the prompt removal of the patient to the hospital. Isolation to the hospital has, however, not been regarded with favour in India either by the poor or the rich, the educated or the ignorant, owing to the inherent desire of

relations to remain by the side of the patient. The next alternative is to isolate the patient in a separate room in the same house, though it is quite impossible to do so in the case of the poor, who have not got more than two or three rooms at their disposal.

Where possible, the room selected for keeping the patient should be situated on the top of the house, and no other room should be used by the inmates on that floor. It should be much better if it is detached from the rest of the building. The windows of the room should be kept open for free ventilation, but the door should remain closed, or a screen of some cloth soaked with some such disinfectant as carbolic lotion may be kept hanging in front of the door, especially in the case of air-borne diseases. No furniture should be kept in the room. A fire may be kept to burn waste matters and also to aid ventilation. No one except the person nursing the patient should enter the room, and he should not leave the room without thoroughly disinfecting his hands and changing his clothes. Food, utensils, clothes and dejecta of the patient should not be removed from the room without previous disinfection. It is better to use a spray of some deodorant all the time in the room. Isolation of the patient should be maintained from the day of infection to the day when the doctor pronounces him free from possible infection to others. The patient should then be given the necessary baths and allowed to mix with other people.

3. QUARANTINE.

This term is derived from the Italian "quarante" meaning forty, and refers to the detention of ships at seaports for a period of forty days as a preventive measure when arriving from infected countries or with cases infected by a dangerous disease, such as cholera. Quarantine is also imposed on travellers going from an infected district into another district or province. The travellers are detained in quarantine camps, where they are inspected and disinfected

along with their baggage, and are allowed to leave the place after the incubation period of the particular infectious disease raging at the time is over. This practice is very objectionable, and has never been regarded with favour by the public, as it causes considerable hindrance to trade and travel. In the beginning of the outbreak of plague the Government adopted this kind of quarantine by having detention camps with a military cordon at several railway junction stations and at some places of pilgrimage as at Hardwar, where the travellers used to be detained for ten days and were allowed to leave the camps after their luggage and they themselves were thoroughly disinfected, but it did not prevent the plague from spreading throughout almost all India owing to the lack of supervision and honesty of the subordinate staff. The people, on the contrary, were put to a lot of hardship and inconvenience, and at some places even riots had broken out.

There would be very little need of adopting quarantine as a preventive measure, if all the communities were to rely on sound sanitation and were to place their cities and seaports in the best sanitary conditions, so that there would be little danger of the spread of an epidemic, even if it could gain entrance there. The only preventive measure in that case would be to inspect the passengers and crew on board ships and to remove the sick to hospitals and to disinfect them. In the case of an outbreak of an epidemic in the cities, the inmates of the house, where infection has occurred, must be kept under a certain degree of quarantine, if the case has not been removed to the hospital, until the last case has ceased to be infectious and the final disinfection has been completed; but if the patient is removed to a hospital and disinfection has been carried out, it is only necessary to keep the inmates under observation for the maximum period of incubation of the disease in question. During the quarantine period, the children from the infected house should not be allowed to attend school, though this is not necessary in the case of enteric fever. Tailors, milk-men, *dhobies*, sweetmeat sellers, etc.,

should not be allowed to carry on their business if an infectious disease has occurred in their household or on their business premises.

The people themselves have begun to realise the importance of this sort of quarantine, and therefore they never allow any shelter to people coming from infected villages or towns. Even in big cities cases have been known in which the inmates of a house were boycotted by the neighbours, because they allowed persons to live with them who had gone there from another infected street.

4. EDUCATION.

The people become panic-stricken when an epidemic breaks out, and so it should be the duty of the sanitary authorities to issue pamphlets and circulars regarding the disease in all the vernaculars of the district to educate them, while other measures should be carried out to combat the disease. The education of the community is essential for the sake of obtaining co-operation, for it is not possible to eradicate an epidemic without the active support of the people. Press *communiques* should be issued in responsible vernacular papers, as was done some time ago by the Government of Bombay with regard to the outbreak of cholera. Lectures and demonstrations, with magic lantern slides, should also be arranged in different *mohallas* of the city. The Sub-Assistant Surgeons in charge of travelling dispensaries can help a good deal in this matter, if they were to start lecturing in the plain vernacular to the people in different villages on epidemic diseases, their causes, their spread and the measures taken to prevent and cure them.

5. DISINFECTION.

By disinfection is meant the destruction of the agents causing infection. A disinfectant is a substance or an agent which is capable of destroying the pathogenic germs, or the infective material. It is synonymous with the term "germicide" or "bactericide." An antiseptic is a substance which prevents

decomposition, and inhibits the growth or activity of micro-organisms without destroying them. A deodorant is a substance which has the power of removing, covering and destroying the unpleasant odours arising from organic matter undergoing fermentation or decomposition. There is a great difference between a disinfectant and a deodorant. The former destroys the germs, while the latter neutralizes only the smell. Thus eau-de-cologne, eucalyptus oil, camphor, Sanitas, and tobacco smoke, are all deodorants, as they remove bad smell, but cannot be considered disinfectants, as they are powerless to destroy the germs causing ill-odorous gases; but we should aim at thorough cleanliness so as to remove the source of the nuisance, so that putrefaction may not occur rather than use the deodorizing substances to conceal the smell of offensive gases arising therefrom, just as the surgeon aims at thorough asepsis in his operations.

Persons undertaking the work of disinfection must be thoroughly conversant with the causes and modes of conveyance of infectious diseases, and they should personally supervise the work instead of leaving it to the irresponsible and inexperienced menial staff.

Classification of Disinfectants.—Disinfectants are divided into three kinds, *viz.*, (1) Natural, (2) Physical and (3) Chemical.

(1) **Natural Disinfectants.**—Fresh air and sunlight are the chief agents of nature, which always destroy infection, and thereby limit the spread of the communicable diseases. The poison of such diseases when exposed to fresh air is very much diluted and often destroyed; hence the importance of free ventilation of a sick-room during and after sickness. Oxygen of the atmosphere plays an important part in chemically acting upon and destroying the infective materials adhering to articles exposed to the air. Drying or desiccation may destroy many non-sporing micro-organisms, such as staphylococci, streptococci, typhoid bacilli, etc., but it has no effect

on the spores of spore-bearing organisms, such as anthrax, even though exposed for a prolonged period.

The action of sunlight as a powerful destroyer of disease germs is due to the actinic rays, especially the ultra-violet rays of short wave length. An anthrax bacillus is killed in one or two hours when exposed to the sun, while its spores are destroyed after thirty hours' exposure to the sun. The effect is enhanced by the presence of air and moisture, and is probably due to the formation of ozone and hydrogen peroxide, two powerful oxidising agents, by the action of the actinic rays on the atmosphere.

On the outbreak of an epidemic of an infectious disease, people must use natural agents to remove infection by observing scrupulous cleanliness in their rooms, keeping them dry and keeping all the doors and windows open so as to allow free ventilation.

(2) **Physical Disinfectants.**—These are fire and moist or dry heat.

Fire is the most efficacious of all the methods of disinfection, and it is the best and the safest thing to burn all the infected articles of little value. Cottages, which can easily be renewed, should be burnt, especially in time of plague. The litter of stables and the refuse of a town should be burnt, especially when some pestilence has occurred. It is safter to cremate all bodies dead of a communicable disease so as to prevent the possible spread of infection from this source. Small quantities of sputum and other discharges should always be burnt rather than disposed of in any other way; but no article should be burnt against the will of its owner, and, as far as practicable, the owner should be compensated by the municipal board for his articles that are burnt.

Dry Heat.—Micro-organisms and even the most resisting spores are killed, when exposed for one hour to a high temperature of 150° C. in a hot-air chamber; but disinfection by dry heat is being given up now, as it is not capable of penetrating into bulky articles like mattresses, while woollen

and similar other articles are always scorched and destroyed by it; it is, however, serviceable for articles of glass, leather, morocco, furs, india-rubber, books, etc., which are likely to be damaged by moisture. It should be remembered that both heating and subsequent cooling should be done gradually to prevent cracking of glass or stoneware.

Moist Heat: (*a*) **Boiling**.—This is one of the readiest and the most effective methods of destroying infections of all kinds. Boiling for 20 minutes kills almost all non-spore-bearing micro-organisms. A few spore-bearing bacteria, such as anthrax and tetanus, are generally destroyed by boiling for one hour. Boiling is suitable for disinfection of bed-clothing, body linen, towels, etc. The albuminous stains of blood, pus and fæces on the articles should be first removed by soaking them in cold water and rubbing them with soap, before they are boiled since heat fixes the stains permanently on account of the precipitation of albumen. Metal utensils, wooden furniture, beds, and floors and walls of an infected room may be disinfected by cleansing them with boiling water. Sodium carbonate should be added if steel instruments have to be boiled.

(*b*) **Steam**.—This is a most reliable and quick disinfecting agent, and has the power of penetrating deeply into bulky articles, such as pillows, mattresses, etc. It destroys vegetating bacteria instantly, and kills most of the spores in a few minutes. Steam may be saturated or superheated. Saturated steam is steam generated under pressure at a temperature higher than that of the boiling water (100° C.), and is at or near its condensation point. Superheated steam is steam heated above its natural condensation point by bringing it into contact with a surface at a higher temperature than 100° C. without increasing the pressure. For purposes of disinfection saturated steam is preferable, since it easily conveys heat and readily condenses to a liquid form on coming into contact with cooler objects. In so doing it gives off its latent heat to those objects, is reduced to $\frac{1}{1,600}$th part

of its original volume, and owing to a partial vacuum thus created, more steam rushes in and thoroughly permeates the objects to be disinfected. Superheated steam is practically a gas, and will not condense until it has lost all its superheat by a slow process of conduction. Hence it has very little penetrating power, and acts by conduction. Its only advantage is that it dries moistened objects.

Whatever be the condition of steam, either saturated or superheated, it is generally employed as current steam or steam under pressure. Current steam is steam escaping from a boiler, as soon as it is generated at the temperature of boiling water. It has the same disinfecting power as boiling water, and destroys infective agents from half an hour to an hour. Steam under pressure has a greater germicidal action than current steam at low or atmospheric pressure. Steam at high pressure means a pressure of about 15 to 20 pounds per square inch. The higher the pressure, the more thorough is the penetration, and the shorter is the time required for killing bacteria. Exposure to a temperature of 115° C. to 120° C. for twenty minutes at an atmospheric pressure of 15 pounds to the square inch is commonly considered quite sufficient to kill all forms of bacterial life including spores.

Steam is used in disinfecting bedding, pillows and other articles of cotton ; but it is injurious to silk and shrinks woollen materials, which lose their colours also. Leather, india-rubber, oil-cloth and varnish also suffer from steam.

Another drawback in using steam is the necessity of an expensive apparatus, to work which a skilled man is needed, and there should be provision also for a disinfecting station.

The air should be expelled from the apparatus before generating steam, for air being a bad conductor of heat prevents the steam from penetrating into the interstices of the articles.

The articles to be disinfected should be packed in gunny bags and sealed up before they are sent away to the disinfecting station.

Disinfecting Station.—A disinfecting station should consist of two rooms provided with sufficient light and ventilation. The walls and floors should be made of some smooth, non-absorbent material to allow efficient cleansing by water. The corners should be rounded off to prevent the collection of dirt, and there should be ample provision for drainage. The rooms should be completely separated from each other by a partition in the middle, and should be provided with the doors at the extreme ends of the building. The disinfecting machine is so placed in the partition between the two rooms, that one end opens into one room which is used for receiving infected articles, and the other end opens into the other room, which is used for receiving disinfected articles. The infected articles on wooden trays are introduced into the machine through one opening, and when disinfected are taken out at the opposite door. There being no direct communication between the two rooms and the persons employed in both the rooms being quite separate, there is no possible risk of re-infection of disinfected articles. There should be separate sheds for carts bringing in infected articles, and for those carrying back the disinfected articles. A laundry and bath-room should also be provided to a disinfecting station, and a charge may be made for any washing done after the disinfection of infected articles.

Steam Disinfectors.—Several types of the steam disinfectors are employed for carrying on disinfection by steam, but those commonly used are the Washington Lyon, the Equifex, the Thresh, the Nottingham Stove and the Sack Steam Disinfector.

The Washington Lyon's Disinfector is a high-pressure apparatus, consisting of an elongated boiler having double walls and fitted with a closely-fitting, air-tight door at each end. The wall of the disinfecting chamber is surrounded by a jacket so as to prevent the loss of heat and to dry the articles after they have been disinfected. It is fitted with a vacuum producing apparatus, and provided with a separate

boiler. Steam is admitted into the chamber at a pressure of 10 to 20 lbs. per square inch, and its penetrating power may be increased by intermitting the pressure during the process of disinfection. When disinfection is complete, steam is cut off from the chamber, while it is continued in the jacket, and thus the articles are dried before they are removed. The whole process of disinfection does not take more than thirty to sixty minutes.

The Equifex Disinfector is worked with saturated steam under pressure. It has no steam jacket, but is provided with coils of hot steam pipes at the bottom and top of the chamber with a view to prevent undue condensation and to dry the disinfected articles. Steam is generated in a boiler quite separate from the apparatus, and is then intermittently admitted into the disinfecting chamber at a pressure of between 7 and 10 lbs. The process of disinfection is usually completed in about 20 minutes.

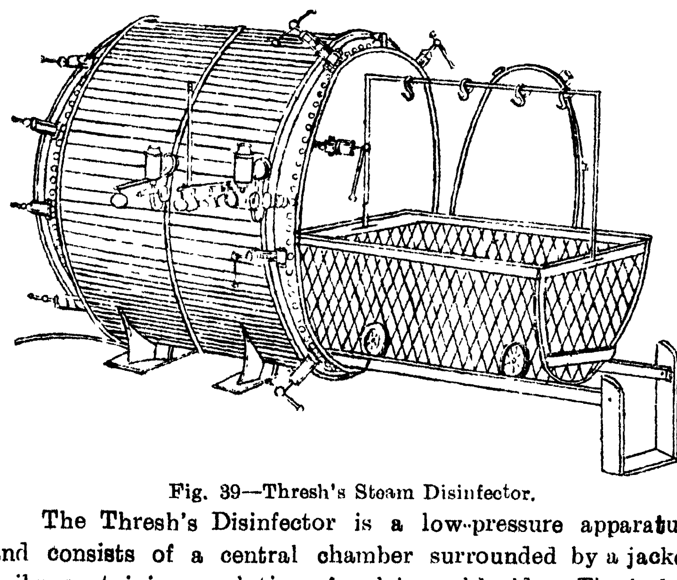

Fig. 39—Thresh's Steam Disinfector.

The Thresh's Disinfector is a low-pressure apparatus, and consists of a central chamber surrounded by a jacket boiler containing a solution of calcium chloride. The jacket

boiler is heated by a small furnace placed underneath, and the steam generated is conducted into the central chamber. Owing to the presence of the salt the water boils at a temperature higher than its boiling point, and the steam is given off at about a temperature of 106° C. without the application of extra pressure. When this superheated steam has passed for a sufficiently long time, it is readily diverted and allowed to escape through a chimney. Hot air is now admitted, and at the end of an hour the articles may be removed quite dry and disinfected. This apparatus is cheap and suitable for small hospitals.

The Nottingham Stove is a high pressure apparatus, and consists of a rectangular chamber having a double wall or jacket. The jacket contains water in its lower half, and serves as a boiler, the furnace being placed immediately under it. The steam is allowed to pass into the jacket and the chamber at a 20 lbs. pressure. A current of hot air is driven into the chamber by means of a vacuum apparatus, so that the articles are warmed and dried before and after disinfection. The time allowed for exposure is usually twenty minutes.

The Sack Steam Disinfector is a new type of a disinfector devised by Colonel P. S. Lelean, Professor of Hygiene at the R. A. M. College, and manufactured by Messrs. Meldrums. It is a cheap, simple and easily portable apparatus with high working efficiency, and is of special value in the mofussil, as well as in pilgrim centres, labour camps, schools and hospitals. It consists of a sack made of steam proof material, 2 feet long and 4¼ feet broad, having a capacity of 13 cubic feet. At the base it is connected by means of hose to a small boiler containing 8 gallons of water. The articles to be disinfected are placed in the sack and the steam enters at the top and displaces the heavier air contained in it which escapes at the tottom. It takes about 15 minutes to disinfect the articles and two to three minutes more to dry them.

(3) **Chemical Disinfectants.**—These are used in all he three states, *viz.*, gaseous, liquid and solid. They act

either by killing micro-organisms, or by preventing their growth and multiplication, or by weakening the microbes, so that they may lose their pathogenic action.

An ideal chemical disinfectant must be cheap and easily obtainable. It must be very strong in its germicidal action. It must be stable in its composition and soluble in water. It must not lose its action in the presence of organic matter like blood, pus, urine and fæces. It should have no poisonous action on men or higher animals, and should be non-corrosive. It should not bleach colouring material, nor should it have any injurious action on any articles of wood, leather, paper, wool, etc.

Gaseous Disinfectants.—The chief gaseous disinfectants are formaldehyde (formic aldehyde), sulphur dioxide, hydrocyanic acid and chlorine.

Formaldehyde is soluble in water, a 40 per cent. solution of it being known as formalin. It is a very valuable germicide and is, therefore, one of the best gaseous disinfectants. It is also a good deodorizer, as it combines readily with the nitrogenous products of putrefaction and fermentation, and forms new odourless chemical compounds. It has no injurious effects upon wool, silk, cotton, linen or metals, and has no action on colours; hence its usefulness in universal application. A certain amount of heat and moisture is necessary for its efficient action. It acts most readily at a temperature of 70° F., and a humidity of 70 per cent.

The vapours of formaldehyde are obtained (1) by heating formalin with 20 per cent. calcium chloride in an autoclave, (2) by heating paraform tablets over a special lamp called the paraform lamp (25 tablets, each containing 1 gramme, are sufficient to disinfect 1,000 cubic feet of space), (3) by exposing formalin to a high temperature in a special generator, and (4) by the combination of formalin and potassium permanganate. When formalin is poured over fine crystals of potassium permanganate in a galvanized iron pail, chemical action takes

place in a few seconds with the formation of formic acid and evolution of heat. The heat liberates the formaldehyde gas. Ten ounces of formalin and five ounces of potassium permanganate are sufficient for disinfecting a room of 1,000 cubic feet of space. The action should continue for six to twelve hours.

Sulphur dioxide is obtained by burning flowers or rolls of sulphur, which are easily procurable in an Indian *bazaar.* Three to four pounds of sulphur should be burnt for efficient disinfection of a room having a capacity of 1,000 cubic feet. Cylinders containing 20 ounces of the liquefied gas are sold in the market and are very convenient. Two such cylinders are sufficient for a space of 1,000 cubic feet.

Sulphur dioxide is a colourless gas having a peculiar suffocating smell. It is a powerful bleaching agent, and readily deprives silk, wool, and other articles of their organic colouring material. It tarnishes metals. It is highly poisonous to mammalian and insect life and, therefore, is very valuable as a disinfectant against diseases spread by rats, flies, fleas, mosquitoes and other insects. A concentration of three per cent. is necessary to destroy rats and vermin.

Fumigation with sulphur dioxide is carried out by burning sulphur moistened with a small quantity of alcohol in some iron vessel, which should be placed in a bucket of water to avoid the risk of fire. The presence of water by its evaporation supplies the necessary amount of moisture required to render sulphur dioxide more potent in its action. It is better to place the bucket and the iron vessel on a high stool or table for complete diffusion in a room as this gas being heavier than air has a tendency to settle down on the floor.

Clayton gas, a mixture of sulphur dioxide and sulphur trioxide is a very efficient vermin killer and is largely used for disinfecting ships. It is generated by burning sulphur in a current of air placed in a special iron furnace, called the Clayton apparatus. The gas is then conveyed to any part of the ship by means of a flexible rubber hose attached to the apparatus.

Hydrocyanic acid gas has no germicidal action, but destroys rodents and insects with great certainty and rapidity. It also destroys the eggs of the insects. Being a deadly poison it must be used with great care. It is very useful for fumigating granaries, stables, outhouses, railway carriages, holds of ships, etc., infested with vermin. It has no harmful effects on metals, fabrics or pigments. The efficacy of hydrocyanic acid gas depends upon its concentration and the period of its exposure. These conditions are such as are obtainable only in fairly air-tight spaces. From experiments conducted at the Bombay Bacteriological Laboratory Gore[1] has found that a concentration of fifty parts of hydrocyanic acid gas per 100,000 of air and an exposure of half an hour are sufficient to kill rats, fleas and bugs. A concentration of six parts of the gas per 10,000 of air kills mosquitoes in a few minutes' exposure.

Hydrocyanic acid gas is lighter than air, and possesses a peculiar and characteristic odour of bitter almonds. For the purpose of fumigation it is generated by the action of dilute sulphuric acid on potassium or sodium cyanide. Gore[1] advocates the use of calcium cyanide for generating the gas. This is a simpler and more convenient method The mere exposure of calcium cyanide to the air results in the evolution of most of the hydrocyanic acid gas in about one hour and a half. One ounce of calcium cyanide per 100 cubic feet of space gives a lethal concentration which is attained in about an hour and a half, and is maintained for about four hours.

Chlorine is both a disinfectant and deodorizer. Its action is increased in the presence of moisture as it combines with hydrogen and liberates oxygen in its nascent state, which bleaches the vegetable colouring matter and prevents, putrefaction by oxidizing organic matter ; but great care should be observed in its employment, as it possesses a strongly irritating smell, and causes pain and even death if inhaled in larger amount.

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1. Calcium Cyanide Fumigation, Ind. Jour. of Med. Research, Oct., 1925, p. 287.

Chlorine is generated by mixing together 8 ouncesof sodium chloride, 2 ounces of manganese dioxide, 2 ounces of sulphuric acid and 2 ounces of water. The reaction can be represented by the following equation :—

$$2NaCl + MnO_2 + 2H_2SO_4 = Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2.$$

It can also be obtained by decomposing hypochloride of lime with sulphuric acid, or by the action of HCl on bleaching powder, or by slightly heating potassium bichromate with concentrated hydrochloric acid.

Ordinarily about 2 pounds of bleaching powder and 1 pound of strong hydrochloric acid or $1\frac{1}{2}$ lbs. of hypochloride of lime and 6 ounces of sulphuric acid should be used for every 1,000 cubic feet of air space. The vessels containing these substances should be placed on high stools, as chlorine being a heavy gas is slow in diffusing. It is necessary that one per cent. of the gas should be present in the air of the room to be disinfected.

Liquid Disinfectants.—It must be remembered that the strength of a liquid disinfectant should not be lowered, when it is added to a fluid, which is required to be disinfected. An excess of it should always be added, so that the same strength might be maintained in the whole bulk of the fluid. To compare the strengths of the various disinfectants Rideal and Walker have proposed a method, which has lately been modified and improved. According to this method a 1 in 100 solution of carbolic acid is taken as a standard disinfectant, and the bacillus typhosus in a 24 hours' broth culture at blood heat is taken as the standard germ. Martin and Chick of the Lister Institute recommend the use of an emulsion of human fæces in place of broth culture to which the test organism should be added. Various dilutions of the disinfectant whose strength has to be ascertained are made, and the highest dilution which destroys the typhoid bacillus in the same time as the standard solution of carbolic acid, is determined by

making experiments. This dilution divided by 100 is known as the **carbolic acid co-efficient** of the disinfectant used.

The following are some of the liquid disinfectants in common use :—

Mercuric Chloride or Corrosive Sublimate ($HgCl_2$).—This is the most powerful and most convenient disinfectant. A solution of 1 in 1,000 destroys non-spore-bearing bacteria, but a solution of 1 in 500 is necessary to kill spores. A warm solution is stronger than a cold one. It is colourless and highly poisonous and should, therefore, be coloured with indigo or aniline colours and kept in special poison bottles. It corrodes metals and so should be stored in non-metallic vessels. It must be used in excess as a large quantity of it is precipitated by organic matter as an albuminate. This can be prevented by the addition of hydrochloric acid or common salt to the solution. The following solution is generally used for disinfecting infected houses :—Mercuric chloride ½ ounce hydrochloric acid 1 ounce, water 3 gallons and 1 grain of aniline blue.

Mercuric Iodide (HgI_2).- This is less poisonous than mercuric chloride, and is not precipitated by albumin to the same extent, while it is twice as strong as mercuric chloride. It is insoluble in water, but is soluble in excess of potassium iodide. It is used very much by surgeons to disinfect their hands. A solution of 1 in 4,000 is used for floors.

Mercuric Cyanide (Hg CN).—This is as powerful as the chloride, but is not precipitated by any albuminous or organic matters. It is, therefore, suitable for disinfecting mud floors smeared with cowdung. An emulsion with kerosene oil and in the strength of 1 in 50 is used for disinfecting plague-infected houses.

Carbolic Acid (C_6H_6O).—This is prepared from coal-tar oil by fractional distillation, and in the crude form is a reddish brown liquid which turns darker on exposure to air and light. It is soluble in 15 parts of cold water, but dissolves readily in hot water. In the pure state it forms colourless crystals,

which become pinkish on exposure to moist air. It is used largely in disinfecting excreta, sputum, soiled clothing and bedding as it does not coagulate albumin. A two per cent. solution kills the ordinary spore-free micro-organisms from three to five hours, but a five per cent. solution should be used to destroy spore-bearing micro-organisms. The action should be continued for a long time. Thus a five per cent. solution will kill the spores of anthrax in two days. The efficiency of the acid is increased by the addition of sodium chloride.

Cresol (C_7H_7OH).—This is also known as cresyl hydrate, and is a mixture of ortho-, meta-, and para-cresols,-isomers-obtained from coal-tar. It is a straw-coloured liquid which becomes brown on keeping or on exposure to light. It dissolves in 50 parts of water, the solution being neutral. The solubility is increased by the addition of alcohol or glycerine. It is less toxic and more effective as a germicide than carbolic acid. A 1 per cent. solution is as active as a 3 per cent. solution of carbolic acid. A 2½ per cent. solution is used as a standard disinfectant in the army.

Izal.—This is extracted from an oil obtained from coke-ovens. It is non-poisonous, and forms a creamy emulsion when mixed with water. It has no harmful effects on textile articles. Klein has found that an emulsion of 1 in 200 destroys non-spore-bearing micro-organisms in 5 minutes, and a 10 per cent. solution kills the spores of the Anthrax bacillus in about 15 minutes. while a 1 per cent. solution in one hour. An emulsion of 1 in 500 completely disinfects typhoid stools in 15 minutes, and an emulsion of 1 in 600 renders typhoid urine aseptic in 5 minutes. An emulsion of 1 in 800 destroys the germs of cholera, typhoid, diphtheria and erysipelas in 5 minutes.

Lysol.—This is obtained by the saponification of cresols. It dissolves in water in all proportions, forming a brown, clear, soapy frothy liquid. It is more powerful as a germicide than carbolic acid, and is usually used in a 2 per cent. solution for surgical purposes. It is much less poisonous than carbolic acid, and does not injure instruments.

Cyllin.—This is non-poisonous and very similar to izal in its properties. On account of its non-injurious effects on clothing, metals, etc., it is largely used now-a-days in disinfecting plague-stricken houses. It is used in 2 strengths, *viz.*, 1 in 160 for disinfecting stools, sputum, floors, etc., and 1 in 320 for disinfecting clothes, furniture, etc. A solution of cyllin and petrol mixed in equal quantities makes a very good disinfectant and insecticide.

Hycol.—This is 18 times stronger than carbolic acid in its germicidal action, but the disadvantage is that it has a tendency to stain clothes. 1 in 200 is used for disinfecting walls, and 1 in 400 for clothes.

Formalin.—This is a commercial name for a 40 per cent. solution of formaldehyde. In a 1 per cent. solution it is a powerful germicide. It is used in the proportion of 10 drams to a quart of water for disinfecting sputum, urine and fæces, and is used as a spray in the proportion of 6 ounces to a gallon of water. The chief advantage of formalin as a disinfecting spray is that it does not damage wall-papers, etc.

Solid Disinfectants.—These are potassium permanganate, lime, chlorinated lime (bleaching powder), ferrous sulphate and soap.

Potassium Permanganate ($KMnO_4$).—The chief use of this salt in India is to disinfect wells contaminated with cholera germs. It readily gives up its oxygen to organic matter, and hence becomes inert very soon. It stains articles of clothing, and cannot therefore be used for disinfecting them; however, its stains can be removed by oxalic acid, hydrochloric acid or lime juice.

Lime or Quicklime ($Ca\ O$).—This is a cheap and valuable disinfectant, but must always be used fresh. It is generally used for disinfecting the discharges of patients suffering from cholera. Dr. Bentley, Director of Public Health,

Bengal recommends the following method for disinfecting a cholera stool :—

A handful of quicklime is placed in the vessel containing a cholera stool, hot water sufficient to cover it is added, and the whole is then stirred with a stick. This will disinfect the stool within a couple of hours.

When a small quantity of water is poured upon lime, heat is evolved, volumes of steam are given off and the solid mass swells up and crumbles into a fine dry powder. This is known as slaked lime or calcium hydroxide. A one per cent. solution of slaked lime will kill many germs in a few hours, and a three per cent. solution will kill cholera germs within an hour. Slaked lime should always be prepared fresh, as it absorbs more water and carbon dioxide when exposed to the air and is converted into calcium carbonate which has no disinfecting properties.

Slaked lime mixed with water is commonly used for white-washing the walls of a sick-room, but their surfaces should always be scraped before they are white-washed.

Milk of lime is the name given to a mixture of freshly prepared slaked lime with 4 to 8 times its volume of water, whereby an emulsion of lime is obtained. It is used as a disinfectant of excreta. A two hours' exposure is sufficient for destroying cholera germs.

Chlorinated Lime (Bleaching Powder).—This is an excellent disinfectant, but rapidly loses its strength in this country especially in hot damp weather, the whole of the disinfecting powers being lost in three weeks after a closed drum has been opened. To be efficient it should contain about 33 per cent. of available chlorine. It may be used as a dry powder or in solution. As a dry powder it is thrown about on the floors of sick rooms and privies, and acts as a deodorant. A 4 per cent. solution of chlorinated lime is used to disinfect the excreta of sick persons. It is very unstable, and should always be kept in stoppered bottles. Chloros, which

is sold in the market in a liquid form, contains 10 to 15 per cent. of available chlorine.

Chlorogen or dibasic hypochlorite of sodium possesses disinfecting properties like bleaching powder, but deteriorates rapidly and has a low percentage of available chlorine. To overcome this drawback Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist of the Agricultural Research Institute at Pusa prepared Electric Chlorogen by electrolysis of a saline solution. This is found to contain a uniform standard of 2.5 per cent. of available chlorine, and keeps practically stable for six weeks in the hot weather; the concentration then gradually falls to 2 per cent., but this percentage is maintained for six months. Lieut.-Colonel Macworth, I.M.S., recommends its use in a 1.5 to 2 per cent. solution in surgical practice both as a bactericide and a physiological antiseptic. The chief advantage is that it does not affect the living tissues.[1]

Chloramine-T (Toluene sodium sulpho chloramide) is non-poisonous, and is very valuable as a general antiseptic. Carriers of the meningococcus are rendered innocuous to themselves as well as to others by inhaling the air charged with a 2 per cent. solution of this salt.

Ferrous Sulphate or Green Vitriol ($FeSO_4$).—This is used as a deodorant, and acts by its reducing action. It is used for disinfecting excreta, drains and gullies.

Soap.—This possesses disinfecting properties owing to the alkalies it contains; but medicated soaps are no good and should not be relied on.

INSECTICIDES OR PULICIDES.

The insects that carry infectious diseases are mostly fleas, flies, lice, ticks, bugs and mosquitoes. They are all killed by fumigation with SO_2, HCN, CS_2 or other irrespirable gases, but it is not possible to carry out thorough fumigation in most Indian houses. Hence we must use other agents that will kill these insects. These are as under :—

Pyrethrum.—This is a popular remedy for killing

1. Ind. Med. Gaz., Oct., 1922, p. 361.

insects, as it is non-poisonous to man and higher animals. The pure powder stupefies flies, mosquitoes and other insects by acting through their breathing pores, when it is sprinkled on them. It is sold as "Persian insect powder." It is used as a dry powder or by its burning fumes. It ignites well, if a little alcohol is sprinkled over it. Two pounds of the pyrethrum powder are usually burnt for 1,000 cubic feet of air space.

Phenol-Camphor.—This is a liquid compound prepared by rubbing up equal parts of phenol crystals and camphor. On moderately heating the liquid, it gives off dense fumes, which rise rapidly and diffuse slowly, and kill mosquitoes, flies and other insects by stupefying them. Care must, however, be taken that it is not over-heated, or else it will take fire and will have no action on the insects. Four ounces of phenol-camphor are considered sufficient for every 1,000 cubic feet of air space.

Pesterine.—This is crude petroleum and instantly kills fleas, bugs and other insects that come into direct contact with it. Rats are killed by pouring it into rat holes. The solution of pesterine made with soap and water is either sprayed to the walls or applied to the floors and walls by means of a brush with a long handle.

Petrol.—This kills fleas on mere contact, and its fumes kill them in about one minute. Equal parts of cyllin and petrol are used to disinfect houses where plague cases have occurred.

A mixture of petrol, benzene and crude petroleum in the proportion of 1 : 2 : 3 forms an excellent pulicidal agent.

Kerosene Oil Emulsion.—This is used according to the following formula :—

Common soap 3 parts, water 15 parts, and kerosene oil 82 parts. Soap and water are first boiled and when all soap is dissolved, the soap mixture is placed in a wooden tub and kerosene oil is slowly poured into it, slowly stirring it until all the oil is absorbed into it. Captain Gloster, I.M.S., found by

experiment that fleas were killed in 2 minutes by a 1 in 1,000 solution of this emulsion. The emulsion should be used diluted with 20 parts of water for earthen floors.

Kerosene Oil and Cyanide of Mercury.—Two parts of cyanide of mercury and 100 parts of kerosene oil are used for killing fleas and other insects in Indian houses; but it is costly, and so its use is limited.

METHODS OF DISINFECTION.

Excreta and other Discharges.—Fæces and urine in typhoid fever, bowel discharges and vomits in cholera, stools in dysentery, sputum in tuberculosis and pneumonia, discharges from the throat and nose in diphtheria, measles, whooping cough and influenza are very dangerous as a source of conveying diseases from the sick to the healthy, and so they should be properly disinfected before they are finally disposed of.

The infected stools, urine, sputum, etc., should be received in vessels made of glass or some other impervious material containing any one of the following disinfectants:—

Acid carbolic solution 10 per cent., izal 5 per cent., cyllin solution 1 in 160, chinosol 1 in 500, solution of formaldehyde 4 per cent., solution of bleaching powder 4 per cent., and equal quantities of fresh quicklime and water.

Whatever disinfectant is used enough should be added to the material to be disinfected so as to maintain the necessary percentage of strength for disinfection; both should then be thoroughly mixed together, and should be allowed to stand covered up for one to three hours. They should then be discharged into a sewer, or in villages and towns where there are no sewers, should be buried deep in the earth far away from a well, or any other source of water-supply. It is still better to burn them after adding enough sawdust.

Articles of Clothing.—Articles, such as towels, napkins, handkerchiefs, blankets, bedsheets, mattresses, and underwear clothing should always be disinfected, if they have been exposed to infection of any communicable disease. They

should be subjected to steam disinfection, if there is an arrangement of a suitable steam disinfecting apparatus. In the absence of this, they should be soaked in carbolic acid 5 per cent., or formalin 10 per cent., or calium hypochlorite 2 ozs. to a gallon, or perchloride of mercury 1 in 1,000, or izal 1 in 20, or cyllin 1 in 320 for at least 12 hours, then boiled for half an hour and washed. The articles that are soiled with such discharges as pus, blood or excreta should be first washed with soft soap and water, before they are immersed in a solution of mercuric chloride or boiled, as both mercuric chloride and boiling precipitate albuminous matter contained in those discharges, and thus render the stains permanently fixed to the clothes.

Silk fabrics which are apt to be injured by boiling should be placed in the sun for three periods of eight hours each. Leather goods, furs and feathers should be carefully wiped over with formalin.

Dead Bodies.—Before they are removed to the burial ground or the burning ghat, the bodies of persons dead from infectious diseases should be carefully wrapped round with a sheet soaked in a strong solution of mercuric chloride, carbolic acid or izal

Houses.—Infected houses are disinfected either by fumigation or by means of sprays. The nature of disinfection depends also upon the nature of the disease. Thus in the case of cholera particular attention should be devoted to disinfection of the fæces, vomit and urine and articles soiled by them ; in the case of plague we should direct our attention to destroy rats, mice and fleas together with destruction of the plague bacillus ; and in the case of malarial fever the chief aim should be to kill anopheline mosquitoes. Another important point to note is that no parts of the house, such as privies, staircases, etc., should be left without being disinfected. In the case of bungalows the servants' quarters and stables should always be disinfected.

Thorough disinfection cannot be carried out unless houses are evacuated, and so the first essential thing is their evacuation by the inmates. Rooms should then be specially prepared for fumigation with either formaldehyde, sulphur dioxide or chlorine. The rooms should be made as air-tight as possible, so that the gas that is generated inside might not be lost through leaks by diffusion ; all the windows, chimney and orifices should be closed tightly, and pasted with thick paper and all the chinks and crevices should be closed by pasting paper or by applying some impervious material. The almirahs, drawers and boxes should all be opened, and kept away from walls, and clothing and other articles contained in them should be hung on strings, so that the gas might freely enter and diffuse through all the corners. The rooms should thus be fumigated for at least six hours. The doors and windows should then be opened, but no one should be allowed to enter until the smell of the gas is driven off.

The clothes and other articles should then be separately disinfected, all wooden furniture, such as bedsteads, etc., should be washed with mercuric chloride lotion, or formalin, or with soap and hot water. The floor should be well scrubbed, the walls and ceiling should be lime-washed and the rooms should then be allowed to be occupied.

In *katcha* houses, or those houses where it is not possible to render the rooms air-tight, disinfection can be carried out by means of disinfecting sprays. Two gallons of a solution should be used for every 1,000 square feet of surface. In the absence of the sprays the surfaces of walls and floors can be disinfected with garden syringes filled with mercuric chloride solution, cyllin or formalin solution or pesterine in the case of plague. The persons engaged in using these sprays or syringes should wear boots, putties and overalls which they should leave behind on leaving the house. Disinfection by sprays should be carried out in the morning so that the rooms might dry by the evening, or it might be necessary to dry

them by burning fire in big *angithes*. The walls of the rooms should always be white-washed before they are occupied.

Fig. 40—Disinfecting Spray.

Privies and bath rooms should be disinfected by izal, carbolic or cyllin lotion, and should be kept thoroughly clean. The walls, seats, and the *gumlas* should also be disinfected. Drains and gullies should be disinfected with a solution of ferrous sulphate in proportion of 1 lb. to 1 gallon of water, or with a solution of hycol or cyllin; or should be sprinkled over with carbolic powder, Sanitas powder, bleaching powder or lime.

CHAPTER XVI.

MALARIA, YELLOW FEVER, DENGUE & FILARIASIS.

MALARIA.

THIS is a very widely prevalent disease, and is spread over almost all the parts of the globe. Generally speaking, the disease is more prevalent in tropical and sub-tropical countries than in temperate regions, and tends to become much more prevalent as the Equator is approached. However, even among such countries certain districts are far more malarious than others, while some enjoy a complete exemption in this respect. In India the Presidency of Madras suffers much less than the Presidencies of Bombay and Bengal, while in Bengal itself it is much more malignant in Lower Bengal and Assam. Jasalmir State is said to be non-malarious.

In temperate regions the disease is active chiefly during the warm season and early autumn, and is usually associated with swamps. The type of the disease is generally mild. In tropical regions it is perennial, though it is most prevalent during and after the rainy season It is also of a more virulent type than in cold and temperate regions. In India it is less prevalent in the first half of the year up to June, but the epidemic, as a rule, breaks out in August or September and reaches its maximum intensity from October to December.

A mean temperature of at least 60° F. and a mean relative humidity of at least 63 per cent. continuously for sixteen days are necessary for the occurrence of malaria. It is largely to be seen along the banks and deltas of large rivers, on low coasts, and around inland lakes and low lying marshy regions. It is said that altitude constitutes a barrier to the progress of this disease, but according to Christophers[1] the highest point above sea-level at which indigenous malaria exists is Quito, a town

1. Byam and Archibald, The Pract. of Med. in the Tropics, Vol. II, 1922, p. 1501.

situated almost exactly on the Equator at a height of 9,000 feet. M. V. Perumal[1] has noticed indigenous cases of malaria, especially of the malignant tertian type occurring at Coonoor Hill at an altitude of 5,600 to over 6,000 feet above the sea-level. From investigations carried out in the Punjab, Lieut.-Colonel C. A. Gill, I.M.S.,[2] has ascertained that the highest elevation in the Himalayas in which indigenous malaria occurs is at a height of 5,000-6,000 feet, while at the hill stations which lie at altitudes of 6,000-8,000 feet, such as Simla, Kasauli, and Murree, it is almost absent, even though anopheles capable of transmitting the disease are found at the last-named station. The absence of malaria at these altitudes is due to the fact that the atmospheric conditions necessary for the establishment of malaria do not exist.

CAUSATION.

The disease is caused by a microscopic amœboid parasite called the plasmodium of malaria belonging to the class "sporozoa." It is a unicellular organism consisting of protoplasm, a nucleus and a nucleolus. It has the characteristic of living at the expense of other cells, hence it is called an endocellular parasite. It possesses amœboid movements, grows and multiplies by fission or spores. This parasite infects birds, sheep, cattle, dogs and man. In man there are three distinct species of this parasite, *Plasmodium vivax*, *Plasmodium malariæ* and *Plasmodium falciparum*. The first two, *viz.*, *Plasmodium vivax* and *Plasmodium malariæ*, cause tertian and quartan fevers of the mild or benign type. The third variety, *viz.*, *Plasmodium falciparum*, which forms "crescents" causes the æstivo-autumnal type of malaria, also called malignant tertian or sub-tertian fever. That these three species of the malaria parasite are quite distinct from one another is demonstrated by inoculating the malarial blood from a diseased individual to a healthy individual. The

1. Ind. Med. Gaz., Oct. 1927, p. 553.
2. Ind. Jour. of Med. Research, Oct. 1923, p. 511.

introduction of a few c.c. of malarial blood in the proper stage will reproduce the same type of the fever and the same species of the parasite which is inoculated.

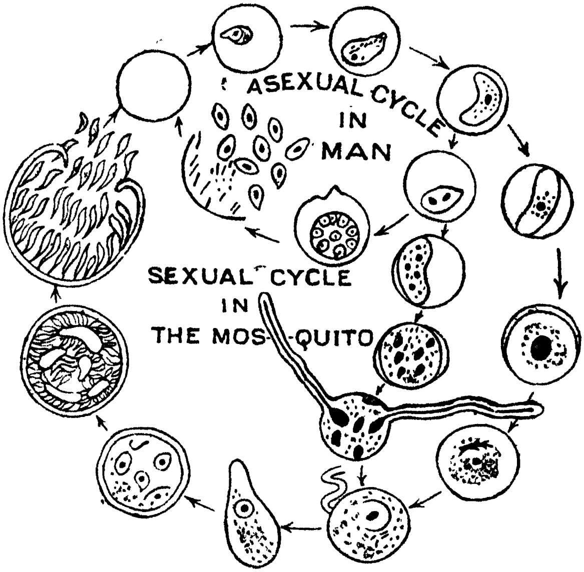

Fig. 41—Malarial Parasite.

The parasite was first discovered in 1880 by Dr. Laveran a French army surgeon in Algeria but it was left to Sir Patrick Manson and Sir Ronald Ross of the Indian Medical Service to find out that the mosquitoes played a very important part in the propagation of this disease. In 1895 Sir Ronald Ross found out that both man and the anopheles mosquito were necessary to complete the life cycle of the malarial parasite, the former being the intermediate host harbours the asexual phase known as the cycle of Golgi, and the latter is the definitive host harbouring the sexual phase of its life cycle. In man it inhabits the red blood corpuscles, and in the mosquito it is parasitic in the tissues of the stomach wall and in the salivary glands.

Life-history of the Malarial Parasite.—The minute rod-shaped form of the parasite, technically called, the

sporozoite, enters the blood of a human being when injected directly from the salivary glands of an infected anopheline mosquito, and forms a starting point of the first phase of malarial infection. In its first stage after entrance into the human blood the parasite undergoes amœboid movement and enters a red blood corpuscle. Stained with suitable stains it is then seen in the red blood corpuscle as a small blue ring with a red dot of chromatin. It is now called a **trophozite.** It slowly gets larger and occupies more and more of the interior of the red blood corpuscle. It is more or less irregular and assumes a blue colour, when stained. The parasite gradually grows larger, feeding upon the substance of the red blood corpuscle and converting the hæmoglobin into dark granules of pigment (**haemozoin**). These pigments can be seen in the parasite. When the parasite has grown nearly to its full size, it almost fills the red blood corpuscle and is called the **schizont**. Next the granules of pigment collect together into a mass, and later on the parasite begins to divide up into a number of small parts or segments called spores, each of which is capable of becoming a new parasite identical in all respects with the original. These parts or spores remain in contact with one another for some time and then burst through the red blood corpuscles and become free in the blood stream. Each of them now seeks out and enters a red blood corpuscle, in which it begins to grow in the same way as the original did, finally reaching its full size and dividing up into a number of embryo parasites which again enter other corpuscles and go through the same cycle. This is the asexual method of multiplication by division called **schizogony.**

After this multiplication has gone on for a number of days, some of the parasites in the red blood corpuscles instead of further multiplying and dividing up, commence to form sexual forms called **gametocytes.** There are two kinds of these sexual forms, *viz.*, male forms called **micro-gametocytes** and female forms called **macro-gametocytes.** Having attained their full size, they appear as coarsely

pigmented round or crescent-shaped bodies enclosed within the thin shell of the red blood corpuscle. They undergo no further development in the blood of man and gradually die off. At this stage of their life-history it is necessary for them to enter the anopheline mosquito to complete their development. When such a mosquito bites a person with these sexual forms in his blood, some of them are carried into the mosquito's stomach with the blood which it extracts, and undergo further development. On account of the action of the digestive juices in the stomach, the thin shell of the red blood corpuscle, which was protecting the parasite while in human blood, gets disintegrated and sets free the parasite in the fluid of the mosquito's stomach. The female sexual form now becomes a granular spherical body and the male, a hyaline one. The pigment of the male sexual form becomes agitated violently, and three or four long filaments called **microgametes** are suddenly protruded from the periphery. These filaments then break off and float about in the fluid in the mosquito's stomach. They are the true male element in the sexual process. When one of them meets a female sexual form, it enters it, and fertilizes the true female element called **macrogamete** contained in it. After this fertilization the female parasite changes its shape and becomes ovoid with a pointed end which is named **ookinet**. It then moves about, and rests between the epithelial and muscular layers of the stomach after entering its inner wall. Here it begins to grow and in a few days attains a large size, when it is called **zygote**.

By a process of division called **sporogony** a large number of embryo parasites called **sporozoites** are formed in the full-grown **zygotes**. After some time the capsule of the zygote bursts, and the sporozoites are set free into the body cavity of the mosquito. They are then carried to the salivary glands through the circulation and deposit themselves into the gland cells and the salivary duct, which opens into one of the piercing stylets of the proboscis. These parasites

are inoculated into the blood of man, when the mosquito bites him, when they at once attack the red blood corpuscles and commence the human phase of the parasite giving rise to the characteristic fever after a certain period of incubation, unless they are killed in the body by spontaneous natural cure or by some artificial medicinal interference. They may also remain dormant in the spleen or some other internal organ until they get a favourable opportunity for development.

The mosquito phase of the parasite's life ordinarily occupies ten to twelve days for its complete development, but under exceptional conditions may require a longer period. The most favourable temperature for development of the malarial parasites within the mosquito lies somewhere about 28° C. Below 22° C. the development of the parasites is more gradual and may take as many as fifty days. Lieut.-Colonel S. P. James, M.D., I.M.S., (Retired)[1] has proved from experiments that a mosquito hibernating over the cold weather can carry malarial infection in the spring. He collected an adult mosquito on August 5th, 1925 and finally dissected it on November 16th, when he found active sporozoites in its salivary glands. He has also proved that freezing does not eradicate the malarial development within the mosquito. Roubaud has suggested that sporozoites which remained for long periods in the salivary glands of the mosquito would degenerate and become non-infective, but it is not so. The mosquito retains its infectivity for from twenty-two to ninety-two days or even longer from the date of first appearance of sporozoites.

INCUBATION PERIOD.

The period of incubation, *i.e.*, the interval between the period of the infected mosquito bite and the appearance of fever is ordinarily nine to twelve days, but it varies, as a rule, with the type of the fever. According to Acton the average

1. Report on the first results of Laboratory work on Malaria in England, by S. P. James, M.D., Lt.-Col., I.M.S., (Retired), assisted by P. G. Shute, Geneva, 1926 : Ind. Med. Gaz., Sep. 1926, p. 451.

period of incubation of quartan fever is 14 days, the maximum being 18 days and the minimum, 11 days. The average period of tertian fever is 11 days, the maximum period being 21 days and the minimum 6 days. That of sub-tertian fever is 6 days, the maximum being 14 and the minimum 2 days.

MOSQUITOES.

Mosquitoes belong to the order of insects known as Diptera and to the family group called the Culicidæ. They can be distinguished from other insects of the same order by a long piercing and sucking proboscis and by having two wings, one on each side with its veins covered with scales.

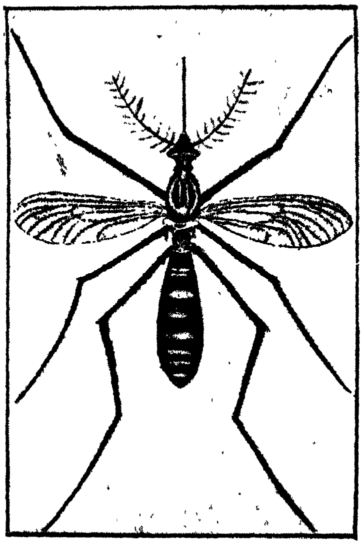

Fig. 42—Anopheline.

Three principal genera of mosquitoes which are important to medical men especially in the tropics are the anopheles, culex and stegomyia. The anopheles is a semi-domestic insect and is found in or near houses, as also in fields, woods and swamps. It is concerned in the transmission of malaria in man. However it is not every species of anopheles that has been incriminated. The chief species of this genus which have been found to carry malaria in India are Anopheles culicifacies, A. turkhudi, A. rossi, A. jeyporensis, A. maculipalpis, A. theobaldi, A. umbrosus, A. willmori, A. sinensis, A. stephensi, A. barbirostri, A. fuliginosus, A. listoni, A. maculata, etc.

The culex is a domestic mosquito, and is commonly found in human habitations in the tropics and sub-tropics

The chief important species are Culex fatigans and Culex pipiens. The former is implicated in spreading the infection of filariasis. The latter is widely distributed in temperate regions, but is not known to convey any human disease.

The stegomyia is a thoroughly domesticated mosquito, and is found all over the world. The chief species is Stegomyia fasciatus (Aedes Argenteus or Ægypti) which is

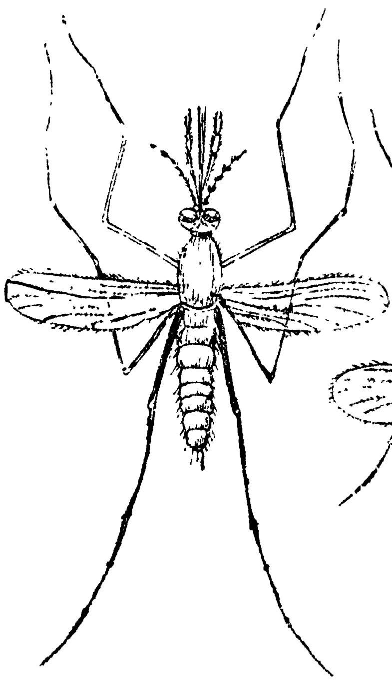

Fig. 43—Stegomyia.

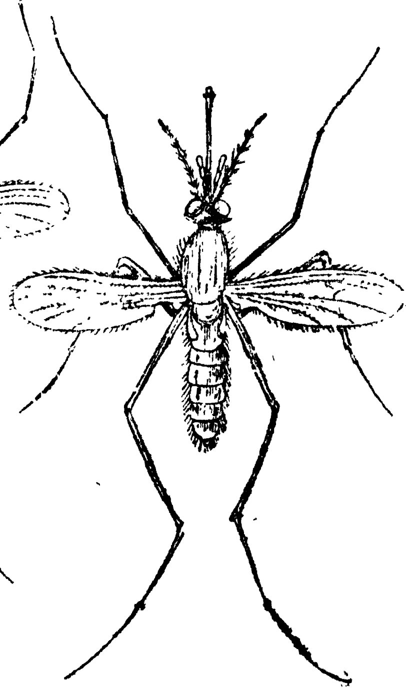

Fig. 44—Culex.

commonly called the tiger mosquito on account of its striped appearance, and transmits yellow fever as well as dengue.

Life-history.—Mosquitoes pass through four stages of development, *viz*., (1) the egg or embryo, (2) the larva, (3) the pupa or the nympha stage, and (4) the imago or the adult insect. The first three stages are passed in water and the fourth stage is mainly passed on the wing.

Eggs or Ova.—The eggs of mosquitoes are usually laid on the surface of the water. The number of eggs laid by a single female mosquito varies considerably from forty to fifty to as many as four hundred. Some female mosquitoes deposit their eggs singly, while others deposit them all at one time in little boat-shaped rafts, known as egg-boats.

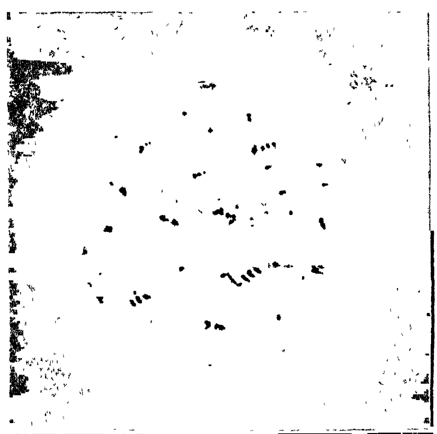

Fig. 45—Anopheline Eggs.

Anopheline female mosquitoes lay their eggs separately, which float as isolated masses scattered irregularly on the surface of the water. When first laid they are white in colour, but rapidly become dark and then black. They are difficult to be detected with the naked eye but, with the aid of a lens may be seen on the margins of small pools, where larvæ are found. Some times they arrange themselves in beautiful star-shaped patterns, parallel rows or triangles. They are about 0.7 to

1.0 mm. in size, and are boat-shaped with two oval air cells on each side which act as floats.

Fig. 46—Culex Eggs.

The eggs of culex, before they are deposited by the female on the surface of the water, are collected together into a sort of a receptacle made by crossing her hind legs so as to form a raft containing several hundreds and held together by a gelatinous material surrounding them. These eggs are, therefore, seen floating on the surface of the water as vertical irregular raft-like masses. These, when first laid, appear white, but soon become black or dark brown in colour. They are broad and oval in shape, and in some cases are elongated.

The eggs of stegomyia float separately on their sides, and are minute and somewhat cigar shaped. They are cream coloured when laid, but rapidly become jet black. They are surrounded by small air-cells, but they are not as large as those of the anopheline eggs. The eggs are highly resistant to unfavourable circumstances. Thus they may remain completely submerged in water for a long time, and then hatch out. They may also be kept in dried mud for some days, and may subsequently hatch out on being brought back into the water.

Larvae.—In from two to three days the eggs hatch out into small worm-like, wriggling creatures, called larvæ, which can be seen quite easily with the naked eye. The larvæ consist of a head, thorax and abdomen, but have no legs. The head is provided with strong mandibles adapted for biting. The thorax is broader than the head, and possesses three

segments fused together to form a single mass. The abdomen is long and slender, and is divided into nine segments. The first seven segments are quite similar to one another. The eighth segment has on its dorsal surface the external openings of the respiratory tracheæ or tubes, which serve to supply oxygen to the tissues of the larvæ. The ninth segment has at its apex the anal opening which is surrounded by more or less well-developed tracheal gills.

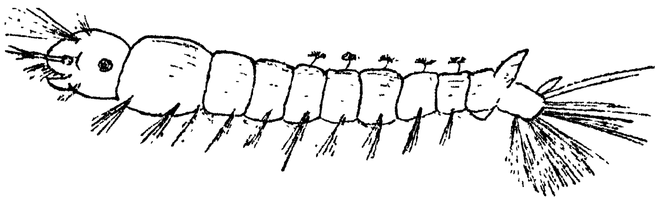

Fig. 47—Larva of Anopheles.

The anopheline larvæ have a black and more or less rounded head and a transparent body. They are provided with two separate apertures of the respiratory tubes placed on the dorsal surface of the eighth abdominal segment and little cup-shaped structures called palmate hairs on the dorso-lateral surface of certain of the abdominal segments. Owing to the presence of these two structures the larvæ float horizontally under the surface of the water. They feed on algæ or green weeds, and are found in puddles and slow running streams or in those pools of water which are not likely to dry up or to be scoured out by rain. They feed chiefly at the surface, but if the puddle in which they are living is only a few inches deep, they sink slowly by their own weight to the bottom to feed amongst the mud or stones and then come up to the surface by making jerking or darting movements.

The larvæ of Culex are dark in colour. They have no respiratory openings on the upper surface of the eighth abdominal segment like the larvæ of the Anophelini, but are provided with a long and thin breathing tube, called syphon tube,

which is a prolongation from the eighth abdominal segment. They have also no palmate hairs. They do not float horizontal to the surface of the water, but hang head downwards with the tip of the syphon upwards, so that their bodies form an angle with the surface of the water. These are the distinguishing features between the anopheline and culicine larvæ.

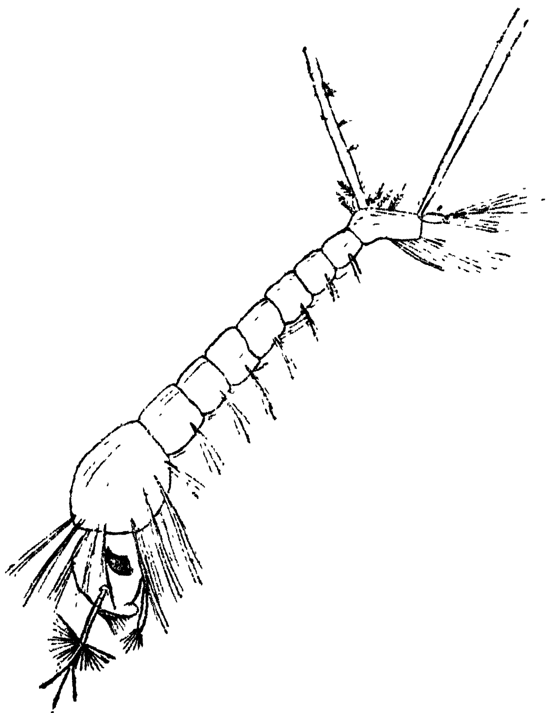

Fig. 48—Larva of Culex.

Culicine larvæ are found in ponds, ditches, pots, tubs, broken bottles or any place where a little water has collected. They are not particular about their food. They feed voraciously on every thing that comes in their way though they seem to prefer animal matter and sewage. When feeding, they are seen to be continually moving forward by the action of their

mouth parts. Sometimes they go to the depth of several feet in water for the search of their food. These larvæ are generally more active than those of the Anophelines, but do not possess the jerking movements of the latter. If disturbed they wriggle at once to the bottom, and often remain there for a long time, if disturbance is continued.

The larvæ of Stegomyia are comparatively colourless, and have a small head with smooth antennæ. They are provided with a short and thick respiratory syphon tube. They have no palmate hairs. When hanging from the surface film of water they maintain an almost perpendicular position, and when disturbed they wriggle down to the bottom, to which they cling for a long time without the necessity of coming to the top for air. Stegomyia larvæ feed largely on decaying organic matter, both vegetable and animal in its character. They are found feeding at the bottom of their dwelling place. The larvæ thrive best in clean or foul water and even in brackish water. They are capable of development in neutral or slightly alkaline water, and soon die in waters containing free acids.

Nymphae or Pupae.—The nympha or pupa stage is almost identical in appearance among all the species of the mosquitoes. The larva casts its skin, two or three times, and attains its full size in from 8 to 12 days in the tropics, and 14 to 20 days in the temperate climates. The time depends entirely on temperature and food. At this stage the larva becomes irritable and swims about in a fitful way and lastly comes to rest. Then quite suddenly a slit appears in the back and after a few kicks and wriggles a comma-shaped pupa creature with a large globular body and a small tail emerges from the skin. This is called the nympha or pupa. It has no mouth, as it does not require any food to eat. It is very active and swims rapidly by lashing the hinder part about. When disturbed it darts to the bottom of the pool, but soon rises to the surface owing to its buoyancy. It does not breathe through its tail like the larva, but does so by means of

a pair of trumpet shaped tubes which project from the dorsum of the thorax. These tubes serve as a distinguishing mark between the pupæ of the three genera of mosquitoes. The tubes of the anopheline pupæ are short, stumpy and funnel-shaped, while those of culicine pupæ are longer, more slender and trumpet-shaped. On the other hand the tubes of the stegomyia pupæ are triangular and broad.

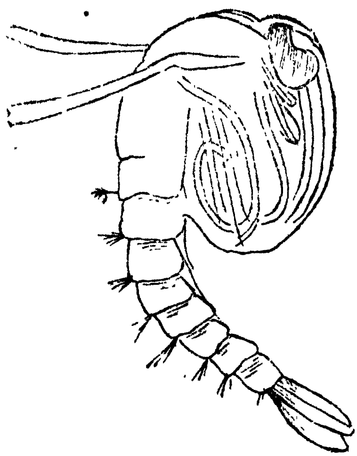

Fig. 49—Pupa of Culex.

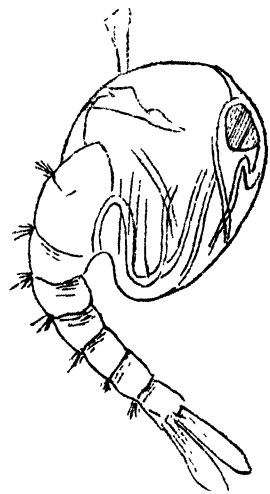

Fig. 50—Pupa of Anopheles.

This pupal stage usually lasts two or three days, and then an adult winged insect (imago) emerges from its case through a rent in the region of the breathing tubes. The imago remains standing for an hour or two on the empty pupal case acting as a rafter, until its legs harden and wings unfold when it flies away in search of its food.

The Adult Mosquito or Imago.—The adult mosquito possesses the head, thorax and abdomen.

The head is small and subspherical, and carries the sensory and suctorial appendages. On the upper surface of the head are situated two large reniform eyes, which meet below

and approach one another very closely above, being separated by a space called the vertex. The portion of the head lying in front of the vertex is called the frons, which is triangular in shape. The antennæ are seen arising anteriorly to the eyes on each side. They are commonly long, slender, flexible and composed of 14 to 16 segments, of which the basal one is large and globular, and is sometimes provided with scales. Immediately behind the eyes lies the occiput, which is covered by scales differently arranged in different genera. These scales are usually described as flat, broad flat, flat spindle-shaped, narrow curved, curved hair-like, upright forked, twisted upright and inflated.

The prolongation of the frons in front is known as the clypeus, under which are situated the mouth appendages consisting chiefly of two lateral palpi and the median proboscis by which the insect pierces the skin and sucks the blood of its victim.

The thorax is composed of three segments, prothorax, mesothorax and metathorax. Of these the mesothorax is the largest and forms the chief region of the midbody. To the under surface of the thorax are attached six long jointed legs, three on each side and a pair of beautiful membranous wings. The wings are long and narrow, the anterior border being straight and thick, while the posterior border being curved and fringed with a row of hairs or long scales. The wings are studded with veins which are more or less covered with scales. These scales form the distinguishing features in the classification of the different genera of the mosquitoes. The respiratory system does not consist of the lungs but of the air tubes called tracheæ which are situated along each side of the body, and communicate with the outside air by means of oval openings called spiracles or stigmata.

The abdomen consists of nine segments, each composed of a dorsal plate, the tergum, and a ventral plate, the sternum. The segments are usually provided with scales or hairs. The anus opens on the ventral surface of the eighth segment,

To the last segment are attached the external genital organs. In the male they are provided at their free end with long chitinous claws forming claspers.

The sexes can be distinguished readily by observing the antennæ with the aid of a hand-lens. In the female the antennæ are long and slender with a whorl of short scanty hairs at each segment, whereas in the male they are short and have a feathery appearance, due to tufts of long and numerous hairs at the segments. The palpi also serve as distinguishing features for the recognition of the sexes. They are usually long in the males, but short in the females. The proboscis is also differently constituted in both the sexes, inasmuch as the female feeds on blood, and the male on vegetable juice.

Classification of Mosquitoes.—The scientific classification of the different genera and species of mosquitoes is based on the shape and character of the various scales on the head, thorax and abdomen. But for ordinary purposes the different genera may be identified by the following features:—

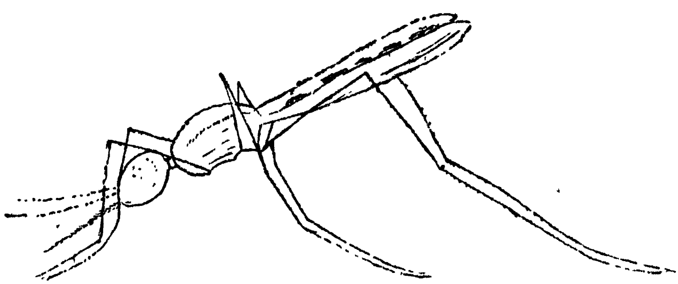

Fig. 51—A Female Anopheles.

In Anopheles the proboscis is thick and long. The palpi of both sexes are long, jointed and club-shaped or clevate, equalling or exceeding the proboscis in both males and females. The legs are long and exceedingly slender, and the wings are small and light coloured, but are generally mottled or spotted, the spots being due to the presence of areas of white and dark scales on the wing veins. When resting on a wall or flat

surface the body is inclined almost at a right angle to the surface, the proboscis held in a straight line with the body.

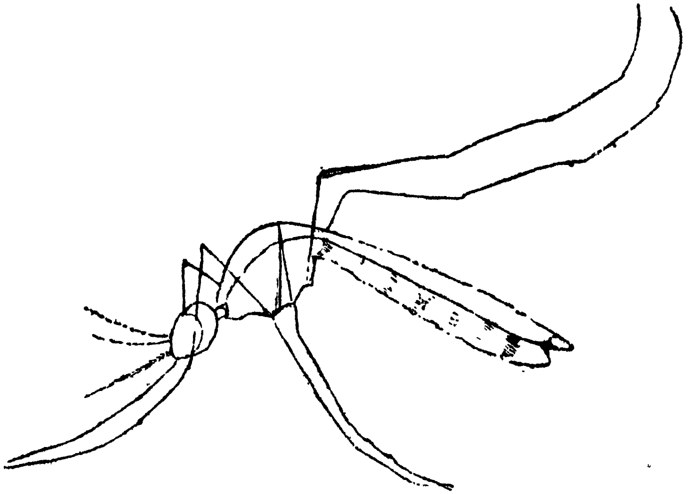

Fig. 52—A Female Culex.

In Culex or Stegomyia (Aëdes) the proboscis is thin and curved. The palpi in the male are usually long and acuminate, but are sometimes short. In the female they are always much shorter than the proboscis. The wings are, as a rule, unspotted, and are brown, grey or greenish black in colour. When resting on a wall the body is parallel to the surface, and has a hunch-backed appearance, the proboscis forming a distinct angle with the body. The Stegomyia is also distinguished by white bands on the legs and abdomen, and a white lyre shaped design on the thorax.

Habits of Mosquitoes.—Adult mosquitoes, especially males, feed on various plant and vegetable juices, but females of most species feed on blood. In fact females do require a meal of blood for fertilization and development of their eggs. Females usually die shortly after laying eggs, if they had not again fed on blood on the previous night. Within a week or

ten days after emerging from the pupa stage the female mosquito becomes active, and is capable of producing eggs. During the course of a season it may lay eggs several times and several hundreds each time. It therefore naturally follows that a pair of mosquitoes can produce millions of mosquitoes in a single season, but bats, birds, fish, lizards, spiders, etc., being their natural enemies, devour them or their larvæ, and thus keep down their number.

In temperate climates many mosquitoes, especially females, pass the winter by hibernating in dark and sheltered places, and become lively again in the spring. They come out of their secluded places, and lay their eggs. Some species hibernate in the larval stage and others in the embryo stage. In tropical countries mosquitoes generally hibernate during the dry hot months of summer, when all the breeding pools dry up. Most of the mosquitoes, however, pass the unfavourable season in the egg stage in the mud at the bottom of the dried pools, and develop when these are again filled with water during the rainy season.

Mosquitoes generally return to deposit their eggs in the very pool, where they were born ; hence such places remain permanent breeding haunts. They rarely wander more than half a mile from the vicinity of their breeding places, and usually not over a few hundred yards. They may, however, be carried to long distances by human agency in ships, railway trains, carts, and other conveyances. It is supposed that mosquitoes are carried away to long distances by strong winds, but it is not so. Being very delicate they dislike strong winds, and conceal themselves in their hiding places, when such wind storms occur.

Mosquitoes prefer dark to light colours ; hence they attack individuals wearing black clothes more readily and repeatedly than those who wear white clothes. During the day they are usually found resting on smoky walls of a room or on the dark strips if the walls of a room are whitewashed

with a dark dado. They may also be seen sitting on dark coloured clothes hanging in the room. They can, therefore, be easily caught in these places. When a mosquito is seen resting on any of these places, the mouth of a dry test tube is placed very gently over it. It will fly into the tube, the mouth of which can then be easily closed with a plug of cotton-wool. This can then be transferred into a large glass bottle. These captured mosquitoes have to be fed on banana and water, and are thus kept alive from two to five weeks. Even though they avoid the diffused light of the sun, they are attracted by the concentrated light of a lamp, hence they can be avoided at night by keeping the bed-room dark and placing a light in the adjoining room, where they will all be lured away.

The age to which mosquitoes may live varies with the sex and species. Male mosquitoes rarely live more than one to three weeks. Females may live four months or more—the period varying in different species.

Habits of Anopheles.—About one hundred and twenty species of Anopheles have been known, and they occur all over the temperate and tropical regions of the world. Some of these are found to transmit malaria, and are always found in malarious districts. It should be noted that every species of malaria-carrying mosquitoes does not transmit all the types of malaria, but a particular species may transmit only one type of malaria but not another.

Anopheles are usually found breeding in the country, especially in rice fields, in the weedy margins of ponds, lakes, streams and rivers, in small sluggish streamlets, in rain water pools lying on grass, in pits hollowed out near railway embankments, etc. But those species which carry malaria are more or less domesticated, and are found breeding near human habitations in any standing water which contains suitable food for them. Thus some of them are found breeding in cisterns and wells in houses and compounds, in pits used for watering

gardens, in stone troughs, in roadside puddles, in gutters, drains and ditches choked with weeds, etc.

Anopheles shun the heat and light, hence during the day they prefer to live in dark almirahs, dark corners of rooms, stables and in the shade of trees and bushes. Towards nightfall when it becomes cool, they come out of their hiding places in search of their food. Females being blood-suckers attack man and other animals. In tropical countries they generally are ready to suck blood within twenty-four to forty-eight hours after emerging from the pupa stage. They usually bite after sunset or in the early morning, but may bite inside houses during the day if it happens to be moist and cloudy. After feeding they usually retire to a dark portion of the room to digest their meal.

The Anopheline female may bite several persons at a time, and if she is carrying malarial parasites, she will infect all of them at the same time, and thus help in propagating the disease. Owing to the Anopheline female's nocturnal habit of biting malaria is generally acquired at night, and a healthy individual may escape the disease, if he visits a malarious place during the day and does not pass the night there.

While flying some varieties of mosquitoes make a sort of humming noise, but Anopheles do not make such a noise. The bite of the Anopheles female is not very painful, and very often people are not aware of having been bitten.

IMMUNITY.

Truly speaking, no human race is naturally immune to malaria, though certain races and certain individuals are less susceptible to its influences than others. Thus, negroes in Africa do not get the fever so frequently and so severely as Europeans living there. Again, the Chinese, the Malays, and some other dark-skinned races also appear to enjoy a comparative immunity—an immunity considerably less pronounced, however, than that enjoyed by the African and West Indian negroes. The cause of this immunity has been explained by

Koch, who says that the men in those regions, where they are constantly exposed to the infection, go through it very often in their childhood and those, who do not succumb to it, acquire a greater or less complete immunity. Owing to the same reason, European children in malarial districts, even though they live under better sanitary surroundings, suffer more from malaria and appear to be of weaker constitution than those born of the local inhabitants who have been immune. One attack does not render a man immune from other attacks, but on the contrary subsequent attacks may be more severe than the first. The new arrivals from non-malarious districts suffer more severely, probably owing to the fact that they do not take the same amount of care and precautions as old residents. They expose themselves to chill and do not take any precautions against the bites of mosquitoes. The old residents, owing to their previous experience, take better care about themselves, and do not act in such a way as their vitality may be lowered and thus may be a prey to malarial infection. People indulging in alcohol, opium and other intoxicating drugs suffer more than people who are sober in their habits. People who burn wood and cowdung in their houses, anoint their bodies with oil and close their doors and windows at night, so that mosquitoes may not enter their houses, do not seem to suffer from malaria so much as others do.

With the growth of prosperity and civilisation, people learn to live in good, well-ventilated, *pucca* houses of two or more storeys and use mosquito nets, and also place themselves under the treatment of qualified medical men, who are, as a rule, found in almost all towns and, therefore, these people are less affected by this pestilence than poor coolies, labourers and cultivators who suffer from poverty and are housed in badly constructed huts.

ESTIMATION OF MALARIA.

The degree of prevalence of malaria in a locality or district or the malaria index as it is called, is ascertained by

(1) examining the annual returns and statistics of hospitals and dispensaries, (2) by ascertaining the proportion of people suffering from enlargement of the spleen, (3) by examining the blood of a number of people to find out how many of them are infected by malaria parasites and (4) by determining the infection among the Anophelines captured in the affected area.

The first method is known as the "fever index," but no reliance can be placed on the first method, as most of the fever cases, whatever their nature, are returned as cases of malaria for want of enough material for correct diagnosis; and in places where there is a facility for correct diagnosis, possibly there is no will on the part of a medical man to take all that trouble to arrive at a correct diagnosis, or that there is not enough time at his disposal owing to his manifold duties.

The second method is easy and fairly accurate in those places, where kala-azar is not prevalent, and can be carried out by an intelligent assistant who is specially trained to feel for the enlarged spleen by pressing the fingers under the costal arch on the left side. Children between 2 to 10 years should be examined for estimating the enlarged spleen, for enlarged spleens become much less common among persons as age advances, owing probably to the establishment of a toleration or partial immunity produced by long exposure to malarial infection. For this method the best thing is to examine children attending a village school. The percentage of enlarged spleens found among children of these ages is called the "Splenic index of malaria."

The third method is more reliable than the first two, but it will give only a minimum rate for malaria in the community, inasmuch as the malarial parasites may not be detected even by an expert after a careful search, if they are few in number in the peripheral blood at the time of the examination, or if quinine has already been administered to the individuals whose blood is examined. Owing to the same reason as

mentioned under the second method, the blood of infants and children under ten years should be examined. The blood films from 30 or 40 children should be taken, and should be examined after proper staining for the presence or absence of malarial parasites. The percentage of such children who have malarial parasites in their blood is called the "Endemic or parasitic index of malaria." When the blood of a sufficiently large number of children has been examined, the figure affords a true index of the degree to which malaria prevails in a place, and affords the most satisfactory means of comparing the amount of malaria in different localities.

The fourth method is known as the "sporozoite" index and consists in capturing the Anophelines prevalent in the infected localilty, noting their species and determining the percentage which, after dissection, show malarial parasites in their bodies.

MORTALITY.

Malaria is a benign and protracted disease, which is complicated and terminated by such inter-current diseases, as pneumonia, cirrhosis of the liver, dysentery, infantile diarrhœa, anæmia, etc. Hence in the event of death it is oftentimes not possible to say definitely whether death has been due to malaria or to any of those inter-current diseases. Besides, the great majority of malaria deaths occur among the children of the poor, who are never treated by medical men, and the cause of death in such cases is therefore never confirmed. Again, the so-called registrar of deaths, who is merely an illiterate *chowkidar* of a village, always attributes malaria as the cause of death in those cases where he does not find prominent symptoms of such diseases as cholera, plague, small-pox, etc. Thus the so-called death-rates are not at all reliable, but one fact is evident, that malaria enfeebles the constitution, and saps away the virility of a nation, and that in India millions of people not only suffer from malaria every year, but are so much enfeebled, that they are unable to follow their usual

avocations. The average life of the people in malarious districts is shorter and the infant mortality higher than in healthy places and so labour and cultivation suffer most. In such districts, owing to the epidemic of malaria enough labourers cannot, very often, be had for reaping the harvest, and the same is the case in tea estates. It has also been observed that people from Lower Bengal migrate to northern India, which is not so malarious as the former. On the whole there is a great economic loss to the community in a country where malaria is very prevalent as in India ; hence all possible measures should be adopted to minimise the incidence of the disease.

PROPHYLAXIS.

For proper and rational prophylactic measures to be adopted, the first step should be directed towards the correct diagnosis of malaria by microscopic examination of the patients' blood, as there are many other morbid processes which simulate the malarial infection.

In adopting the preventive measures the watchwords ought to be (1) protection against mosquito bites, (2) destruction of the mosquitoes, (3) quinine treatment, and lastly, (4) education.

(1) **Protection against Mosquito Bites.**—Houses should be built on an elevated place, and far from marshes and swamps, so that the mosquitoes do not reach there. A row of tall trees if planted near the house will screen it from swamps, but the trees must not be too close, or else they will serve as shelter to the insects. In order to render the houses mosquito-proof they should be encased in fine wire gauze netting. To effect this successfully the netting should be fixed to the verandahs, in which should be door ways made of light wooden frames covered with fine wire gauze netting and provided with automatic spring hinges. If this is not possible owing to the cost, the houses should be provided with wire gauze or bamboo chicks over doorways, windows and sky lights.

Beds should always be provided with mosquito nets. These should be made of fine texture to keep out the mosquitoes, but should allow the free passage of air. They should have no holes and should be hung inside the poles of the bed. The lower part of the net should be tightly tucked underneath the bedding before retiring to bed. Persons suffering from malaria are dangerous to the inmates living in the same house; hence they should be compelled to sleep under mosquito nets.

People residing in a malarious district should avoid going out between sunset and sunrise, but if they have to go out, they should protect the face and neck from mosquitoes by wearing a veil over the head, the hands by wearing thick gloves or gauntlets, and the ankles and feet by wearing thick socks, puttees and boots. During the last Great War the troops in the malarious districts had to use head nets made of muslin draped on metal or cane rings of wide circumference and gloves or gauntlets of finely woven cotton material during the hours of exposure to the mosquitoes. They were found to have a certain protective value.

People whose business carries them to malarious localities should take care not to sleep there at night, but should go back to their places after they have finished their work, during the day-time. Cultivators, who work in their fields during the day-time, should not remain there at night, but should go and sleep in houses built on elevated spots. If their houses are situated in low-lying localities, and if the subsoil water is very much near to the surface, eucalyptus, palms and other quick-growing trees should be planted, so that they will absorb a large quantity of water and render the soil dry.

At bed time the body should be anointed with any one of the following preparations, called culicifuges, which would drive away the mosquitoes:—

Ointments or liniments made with eucalyptol or camphor, oils of eucalyptus, lavender, sandalwood and peppermint, lemon juice, vinegar, petroleum, ammonia, a mixture of tar and oil, and vaseline and many other patent fluids sold in the

bazaar. A few drops of any of these substances may also be sprinkled on pillows at night, or a cloth sprinkled over with a few drops may be hung over the head of the bed; but all these cannot be very efficacious and lasting till the morning, as on account of their volatility their action can only be transitory.

Fans of palm leaves are very good to drive away the mosquitoes and to keep the body cool at the same time. *Punkhas* and electric fans, wherever they can be afforded, are the best means to drive them away, as they avoid strong currents of air.

(2) **Destruction of Mosquitoes.**—For the extermination of mosquitoes the most effective measures are those which aim at destroying their breeding places, their larvæ and the adult mosquitoes. To obtain the best results both individual and communal efforts are necessary.

Destruction of Breeding Places.—Natural collections of water, which may serve as breeding-places, should be filled in or drained. Hollows and pits in the ground should be filled up with inorganic refuse, such as pieces of stones, tiles, cinders and ashes, and the ground should be so made that no water should collect, or they should be filled by earth dug up from a neighbouring hill or mound, but care should be taken that in removing earth no depression capable of holding water should be made. Low marshy lands adjoining the rivers, lakes or the sea should be filled by pumping silt or sand.

When filling is not practicable, *nullahs,* pools and marshes should be drained into neighbouring running water-courses by constructing ditches. These ditches should have a sufficient fall, so that no water should stagnate in their course. They should have straight sides, and should be inspected frequently to see that they do not become choked. There should be proper arrangement for under-draining of the soil, so that it may remain dry in the neighbourhood of villages and towns which are irrigated from canals.

Mosquitoes breed in water barrels, cisterns and tubs used for storage of water. Towns and cities should, therefore, be

provided with the modern closed system of water-supply, so that there should be very little necessity for storage of water within the premises of the houses. But where it is not possible owing to enormous costs involved in the system, all cisterns, tubs, reservoirs, etc., must be well covered with tightly fitting wire-gauze coverings, so that mosquitoes might not breed in them but at the same time there should be enough æration of water. Wells, which are a chief source of water-supply in villages and towns, should be provided with lifting pumps, and should have closely fitting lids. The streets in the cities and towns must be all paved and their drains should be made *pacca*, and should always be brushed and kept clean. If there are any cesspools, they should be done away with, or should be connected with drains.

Broken bottles and crockery, empty broken tins, flower pots and old buckets, which are likely to harbour mosquitoes, should not be allowed to lie about in the compound of the house but must be collected in suitable dust-bins.

Destruction of Larvae.—The drugs which destroy mosquito larvæ are known as larvacides. The larvæ come up to the surface of water to breathe, so that they can be easily killed by pouring on its surface some substance which will asphyxiate them by blocking their air passages. The substance that is generally used for this purpose is kerosene oil or crude petroleum. Approximately an ounce of the oil to every fifteen square feet of surface is sufficient, and ordinarily the application need be made only once a month. The entire surface of the water should be covered with a thin film of the oil, which would suffocate all the larvæ coming to the surface and prevent the mosquitoes from depositing their eggs. For small pools a piece of cloth should be tied to a long stick and dipped into kerosene oil which should then be spread over the water surface. For a big lake a rope sufficiently long to reach its sides should be taken and in its centre a big piece of cloth dipped in kerosene oil should be tied. Two persons should then hold the two ends of the rope standing on the opposite

sides of the lake, and should move the cloth about on the surface of the water, so that the whole surface will be evenly oiled. A mixture of equal parts of kerosene and crude oil is often used as a larvacide. Crawford and Chalam[1] have found a mixture of crude oil and crude carbolic acid (20 per cent.) in equal parts as highly satisfactory. The larvacide used in enormous quantities at Ancon, C.Z., is made of crude carbolic acid, powdered resin and caustic soda, heated together to make a black liquid resin soap which readily forms a milky emulsion with water. One part of this emulsion in 5,000 parts of water kills Anopheles larvæ in sixteen minutes. It also kills larvæ in mud, and destroys grass, algæ and water weeds in which larvæ ordinarily hide.[2] Recently tar preparations, such as cresol, cyllin, izal and newcol, have been recommended as larvacides. More recently Paris green, aceto-arsenite of copper, has come largely into use as an efficient larvacide. It is used in the form of a powder. mixed with fine cork, saw or dry road dust. A dilution of one part of Paris green in 100 parts of dust is said to be sufficient for larvacidal purposes according to the Bulletins of the United State Public Health Service. Dalal and Madon[3] have found that saw dust and fine road dust have a tendency to sink to the bottom and do not withstand agitation or wind action. Hence they recommend the use of French chalk as a diluent of Paris green. It is finely powdered magnesium silicate and forms a very thin, even film on the surface, which lasts for about four days, if the water is undisturbed as in the case of a closed tank, and almost refuses to be drowned by agitation. It is readily obtainable in an Indian *bazaar* as smooth hard pieces under the vernacular name of *sangzira.* 40 grains of Paris green mixed with 8 ounces of French chalk are sufficient to be sprinkled on

1. Mosquito Reduction and Malarial Prevention, 1926, p. 63.

2. Asa C. Chandler, Animal Parasites and Human Disease, 1922, p. 459.

3. Ind. Med. Gaz., Oct. 1927, p. 554.

the surface of about 500 square feet. Sublimed sulphur may be used as a substitute for French chalk.

There are many other larvacides, *viz.*, sulphuric, hydrochloric and other acids, potassium permanganate alone or mixed with hydrochloric acid, sulphate of copper, perchloride of mercury, carbolic acid, aniline dyes, leaves of strong tobacco, and powders from unexpanded flowers of chrysanthemums, but all these being poisonous, should only be used in water not meant for drinking purposes, and should be used in large quantities to be thoroughly efficacious.

The natural enemies of Anopheline larvæ are certain species of small fish, which have been successfully employed for destroying them. "Millions" of Barbados have been found the most effective larvæ-eating fish, and have been imported into India and other tropical countries, but the results have not been always satisfactory, as they do not get acclimatised to their new surroundings. In India the chief variety of fresh water fish which devours Anopheline larvæ is known as *Haplochilus lineolatus* (*Piku*) belonging to the group of *Cyprinodontidæ.* It is a hardy little fish, stands transfer from one place to another extremely well and can be acclimatised to live in brackish water. Sewell and Chaudhuri[1] have found that three of these small fish are sufficient to prevent any larvæ developing in a small aquarium having a surface area of one foot six inches by two feet six inches. The other varieties of larvivorous fish described by them are *Haplochilus panchax* (*Panchoke* or *Lal Jhingra*), *Trichogaster fasciatus* (*Khalse* or *Khalas*), *Badis badis* (*Chiri* or *Bhedo*) and *Anabas scandens* (*Koi, Kavai* or *Kazara*).

Destruction of Adult Mosquitoes.—The substances that are used to kill mosquitoes are called culicides. They are divided into odours, fumes and gases. Among the odours which cause death are oil of turpentine, iodoform, menthol, nutmeg,

1. Indian Fish of Proved Utility as Mosquito Destroyers.

camphor and garlic. There is a custom among the people of hanging small bags containing garlic or camphor round the necks of sick patients, especially the children, with an idea that the evil spirits may be warded off. It is doubtful whether these spirits will be thus kept at a distance, but in malarious places mosquitoes will certainly avoid biting such people.

Among fumes, the smoke of tobacco is very efficacious, as it kills mosquitoes in two or three minutes. Ordinarily people burn green *neem* leaves and horses' litter with cowdung cakes in stables and huts to drive away mosquitoes. Smokes of pyrethrum powder, chrysanthemum flowers, fresh eucalyptus leaves, quassi wood and simple .wood are also beneficial. Among the gases the most practical and efficacious is sulphur dioxide obtained by burning sulphur. The other gases that can be used are sulphuretted hydrogen, coal gas and formaldehyde.

Bats, birds, lizards and dragon-flies are the natural enemies of mosquitoes, but they themselves are a nuisance if introduced into dwelling houses to kill mosquitoes and in that case, the remedy will be worse than the disease. Large numbers of mosquitoes can be destroyed in houses by a small hand-net as suggested by Major Ross. Mosquito traps of wooden boxes painted black or lined with black cloth on their inside may be placed in the rooms to catch mosquitoes, which may be killed by pouring benzene or petrol through the small hole on the top, and may then be removed. The hole should be closed with a cork, so that mosquitoes may not fly away.

During the breeding season of mosquitoes, it should be the duty of every municipal board in malarious districts to employ gangs of coolies called *mosquito brigades*. Each gang should consist of three or four men and a headman, who should be responsible for the work of the gang. All the gangs should be placed under a medical man or a sanitary inspector. The duties of these gangmen should be to keep street gutters, surface drains, road-side ditches and channels, margins of ponds and streams clear of weeds and obstructions, to fill up

breeding pools or ponds or to oil them, to inspect the compounds of houses at least once a week and to destroy all the breeding-places.

(3) **Quinine Treatment.**—As the source of infection, *viz.*, the malarial parasite, resides in the blood of man, it is necessary to treat the malarious patient effectively, so that he may not be a source of danger to others. The best way to do this is to disinfect the blood by administration of quinine which is the specific disinfectant for amœboid organisms, and consequently for the malarial parasi tes in the amœboid stage. The best time to give quinine to patients is the sweating stage, when the greater number of amœboid forms of the parasite are present in the circulation. These will be killed by quinine, and thus the recurrence of another paroxysm of fever will be prevented. Several preparations of quinine are used for this purpose, but acid hydrochloride of quinine seems to be quicker and more efficacious in action than sulphate or bisulphate, and a comparatively smaller dose is required as it is rapidly absorbed in the blood. Malarious patients should be treated free of charge. For this purpose five-grain packets of quinine are sold at a nominal price at all post offices, and quinine pills are distributed gratis among the people in villages. Quinine acts also as a prophylactic and should, therefore, be given to every one in a locality where malaria breaks out, but it is very difficult to persuade healthy people to take it, as it is a very bitter medicine. Again poor and ignorant people, who are, as a rule, averse to allopathic treatment, will object much more strongly to a routine treatment of quinine, when they are apparently healthy; however, this treatment is nowadays adopted in jails, schools, barracks and police lines, wherein the number of malarious cases has diminished to an appreciable extent.

There are three principal methods of administering quinine as a prophylactic: (*a*) five grains every day after breakfast, (*b*) ten grains on two successive days in a week, or (*c*) 15 grains once a week. Those who have an objection to

taking of powders or solutions owing to their bitter taste should be given freshly prepared pills or tabloids. Children can be persuaded to take pills more easily than bitter solutions, but the old dried pills should not be used, as they are not liable to be absorbed, but pass out unchanged along with the fæces.

Lieut.-Col. Acton, I.M.S., has proved that cinchona feleri-fuge can take the place of quinine both as a curative and preventive remedy for malaria and being cheaper a large amount of money can be saved.

(4) **Education.**—All the sanitary measures described above to eradicate malaria cannot be effectively carried out without the co-operation of the people for whose benefit they are intended; it is specially so in India where people are steeped in ignorance and superstition. Co-operation cannot be secured, unless the rationale of these measures is thoroughly understood. The sanitary authorities should, therefore, try to educate people in malarious districts on the mosquito-malaria theory by issuing pamphlets in vernaculars from time to time, and by organizing popular lectures on this subject, illustrated with magic lantern slides, or cinema films, if possible.

YELLOW FEVER (TYPHOID ICTEROIDES).

This is a disease of the tropics, and is endemic in the West Indies and West Africa. From these places it spreads in an epidemic form to other areas, where conditions more or less tropical exist. In most cases the disease is conveyed by means of shipping.

Aetiology.—The causative organism of yellow fever which was discovered by Noguchi in 1918 is a spirochæte, to which he has given the name *Leptospira icteroides*. It is an extremely delicate filament with short and very regular spirals. It is smaller than the Spirochæte of Weil's disease. It is actively motile and very difficult to stain by most aniline dyes. It is best studied under dark back ground illumination. It is found in the blood serum and also in the liver and

kidneys. Noguchi has been able to obtain this organism in pure culture both from the blood of patients suffering from yellow fever and from the blood of inoculated animals.

It is present in the peripheral blood of the patient only during the first three days of the disease, and is destroyed by an exposure to a temperature of 55° C. for ten minutes.

Incidence.—It is chiefly a disease of the sea-coast towns, the banks of rivers and flat delta country, and for its development it requires an atmospheric temperature of over 75° F. It never spreads when the temperature is below 68° F. Both sexes of all ages are susceptible to the disease, men possibly more than women.

Incubation Period.—The period of incubation is usually 3 to 5 days, though in rare cases it may be as short as 36 hours and as long as 13 days.

Mode of Infection.—The disease is conveyed through the bite of an infected mosquito, the *Stegomyia fasciata,* now called, Aëdes argenteus. The mosquito becomes infected only if it has sucked the blood of a yellow fever patient during the first three days of the fever. Further it is capable of transmitting the infection to other persons after at least twelve days have elapsed since feeding on the infected blood. During this period the disease germ undergoes its cycle of development in the body of the mosquito. The infected mosquito remains infective during the rest of its life, which may extend to four months or more; only the female mosquito transmits the virus, and may transmit it to a new generation of mosquitoes developed from its eggs, if laid 12 days after infection.

Habits of Stegomyia fasciata (Aëdes Argenteus).—This mosquito is widely distributed throughout the tropical and subtropical regions. It is always found in the vicinity of human habitations, and shows a decided preference for human blood. It is found breeding in small collections of water, such as stagnant pools, cisterns, barrels, buckets, old

cans, water pitchers, flower pots, broken bottles, tree-holes, etc. It is diurnal in its habit and bites chiefly during the afternoon. It generally attacks the exposed ankles, but if it finds them protected, it crawls up under the clothing and bites the legs. It is noiseless in its approach to man and its bite is painless. Being a domestic insect it is seldom found wandering away from its breeding place beyond a few hundred feet. It apparently does not hibernate but disappears, when the temperature falls below 59° F.

The female Stegomyia deposits her eggs upon the surface or near the surface of water usually within four to seven days after a meal of blood. She deposits them singly in separate lots, the number varying from 25 to 75 or more. Under favourable conditions the eggs hatch out into larvæ from ten hours to three days. The larva attains the pupal stage from six to seven days, the time depending upon the temperature and food supply. The imago emerges from the pupal stage under normal conditions from thirty-six to forty-eight hours.

Immunity.—No race is immune to this disease, inasmuch as Europeans, Indians, Chinese and Negroes suffer from the disease, though dark races are popularly believed to be less susceptible than white races. One attack of the disease confers immunity against a subsequent attack, and this acquired immunity is very strong, and lasts throughout the life-time of the individual.

Prophylaxis.—This consists largely in adopting sanitary measures for the eradication of Stegomyia mosquitoes. All water tanks and cisterns should be covered with fine meshed metallic gauze. Cesspools and other small pools of stagnant water should be treated with crude oil at least once a week.

Ships leaving infected sea-ports should be thoroughly fumigated with the object of destroying mosquitoes, which might have been carried on board in baggage or otherwise. Ships coming from infected ports should be anchored at least

a quarter of a mile from the shore and from other ships in the harbour for at least six or seven days. Sailors and other crew of such ships must not be allowed to disembark on shore unless medically examined.

Cases of yellow fever should at once be notified, and the patients should be immediately isolated to mosquito-proof rooms or wards of a hospital. Their beds should be covered with mosquito nets with 20 meshes to the inch. The room occupied by the sick person after he has vacated it should be thoroughly fumigated by burning sulphur, pyrethrum or tobacco.

Noguchi has prepared a prophylactic vaccine from the killed cultures of the organism, *Leptospira icteroides*, and recommends 2 c.c. of it to be inoculated twice at an interval of ten days. Immunity is conferred in ten to fifteen days after the last inoculation.

DENGUE (DANDY FEVER, BREAKBONE FEVER).

This specific febrile disease occurs during the dry hot season of tropical and subtropical regions. It is very similar to yellow fever, inasmuch as it is prevalent along the coastal towns, and in the valleys and deltas of large navigable rivers, but like influenza, it very often spreads in a pandemic form over large areas along the trade routes, and attacks almost every one in the community.

Aetiology.—The exact nature of the virus has not yet been isolated, but it is filterable and resides in the peripheral blood. The filtrate or the unfiltered blood of patients induces the disease when inoculated into susceptible individuals. Cleland, Bradley and McDonald found during their investigations that the virus was present in the blood up to ninety-nine hours after onset, and that the drawn blood retained its infectivity for seven days if kept in the ice chest.[1]

Mode of Infection.—In 1903 Graham proved from experiments that the disease is conveyed from the sick to the

1. Ind. Med. Gaz., Dec. 1926, p. 614.

healthy through the bite of the tropical mosquito, *Culex fatigans* (*quinquefasciatus*), and that it is not contagious. Ashburn and Craig confirmed this view by working in the Philippines. Recently, however, Cleland, Bradley and McDonald in Australia and Archibald in the Sudan have definitely proved that the disease is transmitted by the agency of *Stegomyia fasciatus* (*Aëdes argenteus or ægypti*) instead of by the agency of *Culex fatigans*. The Medical Research Board have also shown by carrying out more recent experiments in the Philippine Islands that *Aëdes ægypti* (*argenteus*) is the true vector of the disease, and that it becomes infective by biting a patient during a few hours before the first symptoms and during the first three days of illness. Infection of the mosquito is more or less uncertain after that time. Having taken the blood of the patient, the mosquito becomes infective only after the tenth day and retains its infectivity probably throughout the rest of its life. Hereditary transmission of the virus does not occur.[1]

Incubation Period.—The incubation period may be on an average 4 to 6 days. In experimental cases Graham found 3 to 14 days as period of incubation.

Immunity.—One attack does not generally confer immunity. Very often persons are known to have been affected at the occurrence of each epidemic. However, fatal cases are very rare.

Prophylaxis.—This consists in screening patients against mosquito bites by keeping them in beds covered with mosquito nets at least for the first three days of their illness, and destroying the mosquitoes and their breeding places.

FILARIASIS.

This disease is largely prevalent in India and other tropical and subtropical countries. It is most common along the sea coasts and near the banks of large rivers. High

1. Ind. Med. Gaz., Dec., 1926, pp. 614, 617.

temperature, and atmospheric humidity are the chief climatic conditions favouring the spread of this disease.

Aetiology.—The disease is caused by the introduction into the human body of nematode worms of the family, Filariidæ, by the bite of a mosquito. Four species of these worms are known, *viz.*, *Filaria bancrofti*, *Filaria loa*, *Filaria perstans* and *Filaria demarquayi*. Of these the first is the most important.

Filaria Bancrofti.—This is also known as *Filaria sanguinis hominis* or *Filaria nocturna*. It is a long, slender, transparent nematode having an incurved or spiral tail. The female measures about three to four inches in length, while in diameter it is hardly bigger than a horsehair. The male is a little less than one-half the size of the female. The males and females are generally found coiled up together in the lymphatic vessels and glands, and mechanically obstruct the flow of lymph in those vessels giving rise to pathological conditions, such as chyluria, elephantiasis, etc. Here they breed, and the females give birth to large numbers of microscopic embryos, which find their way into the blood stream through the lymphatics and the thoracic duct. These are delicate, colourless, worm-like organisms, measuring from 1/100th to 1/80th of an inch in length and having a blunt anterior end and a tapering posterior end, and are enclosed in a loose transparent sheath inside which they are seen moving backwards and forwards. During the day they live in the lungs and blood vessels of the thorax, and come into the peripheral blood at night time, when the infected person is sleeping. Owing to this nocturnal periodicity they are called *Microfilariæ nocturna*.

Filarial Mosquitoes.—The filarial embryos are incapable of further development within the body of their human host, but complete their life cycle within the body of mosquitoes, which serve as intermediary hosts. *Culex fatigans* (*quinquefasciatus*), the commonest house mosquito of the tropical countries, is the chief species which is concerned in the

transmission of this parasite. Roy and Bose[1] have also found that *Culex fatigans* acts as the intermediary host at Puri, which is a notorious endemic area of filariasis. This mosquito is brown in colour and has a broad whitish band on each abdominal segment. It breeds in stagnant collections of dirty brackish water, such as cess-pools, road side drains, etc. It is nocturnal in its habits, and bites in complete darkness. This probably accounts for the nocturnal periodicity of Microfilariæ. Other species of this genus which are concerned in the development of these parasites are *Culex pipiens* in Cuba and *Culex ciliaris* in China. The other genera of mosquitoes which have been found to serve as intermediary hosts are *Anopheles (Nysso-myzomyia) rossi*, *Anopheles (Myzomyia) costalis*, *Aëdes variegatus (Stegomyia pseudoscutellaris)* and *Aëdes (Finlaya) togoi*.

Within an hour and a half after the mosquito has fed on the blood of an infected individual, the microfilariæ cast off their sheath, and move freely in the viscid blood within its stomach. They then pass through the stomach wall and enter the thoracic muscles by the second day. Here they grow, develop into larvæ and reach their full size of 1/25 to 1/20th of an inch in length having a complete alimentary canal with mouth and anal openings. They next leave the thoracic cavity and migrate to the head parts and finally reach the labium, where they await an opportunity to re-enter a human host. When this mosquito bites an individual, the larvæ emerge from the proboscis and enter the blood burrowing through the skin in the immediate vicinity of the puncture caused by the stylets of the mosquito. They then develop into the adult stage and pass into the lymphatic vessels.

The time taken up for the completion of the life cycle of these parasites within the mosquito varies from 10 to 14 days under favourable conditions of high atmospheric temperature

1. Ind. Med. Gaz., Aug., 1922, p. 281.

and moisture, but may be six weeks or more during cold. During their investigations at Puri in India Roy and Bose[1] noted the time to be about 18 to 20 days.

Prophylaxis.—Patients suffering from filariasis are dangerous to the community, hence they should be compelled to sleep under mosquito nets. The people living in the areas where the disease is endemic should also sleep under mosquito nets to avoid bites from infected mosquitoes. At the same time measures should be taken to destroy the breeding places of the mosquitoes.

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1. Ind. Med. Gaz., Aug., 1922, p. 285.

CHAPTER XVII.

PLAGUE.

THIS is the "Black Death," or "Pestilence" of the Middle Ages, and "Mahamari" or "Pali plague" of India. It is endemic in Garhwal, in the valley of the Yunan, on the eastern slope of the Himalayas, in Mesopotamia and in the interior of Africa near the source of the White Nile in Yuganda. From these places it has often spread in an epidemic form over Asia, Africa and Europe from very early times.

The present epidemic of plague has been raging in India for the last thirty-two years. It first broke out in Bombay in 1896. It is not settled as to how plague was introduced into Bombay, though the following theories have been advocated by medical men working into its epidemiology :—

1. There was plague in Hongkong and in China in 1894, 1895 and 1896, and so it is possible that it might have been imported from Hongkong or southern parts of China.

2. It might have been conveyed from the Persian Gulf, the disease being endemic in Mesopotamia.

3. The pilgrims from Kumaun and Garhwal might have brought the infection to Bombay.

In 1896-97 the disease was practically limited to the Presidency of Bombay, but during the subsequent years it spread to the other presidencies and provinces, particularly Bengal, Punjab, United Provinces and Central Provinces. In 1906 the disease also broke out virulently in Burma, and during 1907 a few cases had been reported west of the Indus. Up till now fortunately the plague has not got its hold on the Presidency of Madras, and Provinces of Eastern Bengal and Assam.

Mortality.—This is generally very high, varying from 60 to 80 per cent. of those attacked. In India, in the twenty years 1898—1918 rather more than ten and a quarter million deaths from plague were recorded, the years 1903-04, 1904-05, and 1906-07 contributing over a million each and 1917-18

contributing about eight hundred and twenty thousand. The mortality usually reaches its height in the month of March, but in April it very closely approximates that of the former month. February, May and January come next. June and July are the months of minimum plague mortality as a whole. Recent returns show that plague is slightly on a decline, about a million deaths having occurred in the whole of India during 1921-25.

ETIOLOGY AND EPIDEMIOLOGY.

The disease is due to the *Bacillus pestis* isolated by Yersin and Kitasato at Hongkong in 1894. The parasite is a very minute cocco bacillus with rounded ends. It has one terminal flagellum. It has also a capsule which is seen specially in the bacilli present in the blood. It is readily stained by aniline dyes, the extremities taking stains better than the central part. The bacilli are found in the tissues lying singly or in pairs, and sometimes in chains.

The bacillus is easy of cultivation, is non-sporing and very soon loses its vitality on exposure to sunlight, drying and other external agencies. It does not exist in nature outside an animal body either in the soil or upon the floors of the houses, and so there is very little danger from these sources.

The plague bacillus gains admission through an abrasion of the skin, except in cases of pneumonic type. In plague cases, the bacillus can, in most cases, be found in the buboes, in the blood, in the sputum, and in the internal organs. In a very few cases it is found in the urine, and then even in a very small number ; but fæces are, as a rule, free from this bacillus.

It has been proved by recent researches by the Indian Plague Commission working in Bombay that plague is primarily a disease of the rat, and secondarily of man ; and that it is transmitted from 'rat to rat' and from 'rat to man' through the agency of the rat flea. It is apparent from the history of the plague that the rat has always been associated with the disease.

Besides rats, there are other animals, *viz.*, mice, guinea-pigs, rabbits, squirrels and monkeys, which suffer from plague, but they are not of much importance, as they are not concerned in propagating the disease in man, though on seeing them dying of plague, people should take necessary precautions against it. However, it has been noted by Major Tucker, I.M.S., that a child got plague after it was bitten by a plague-infected squirrel.

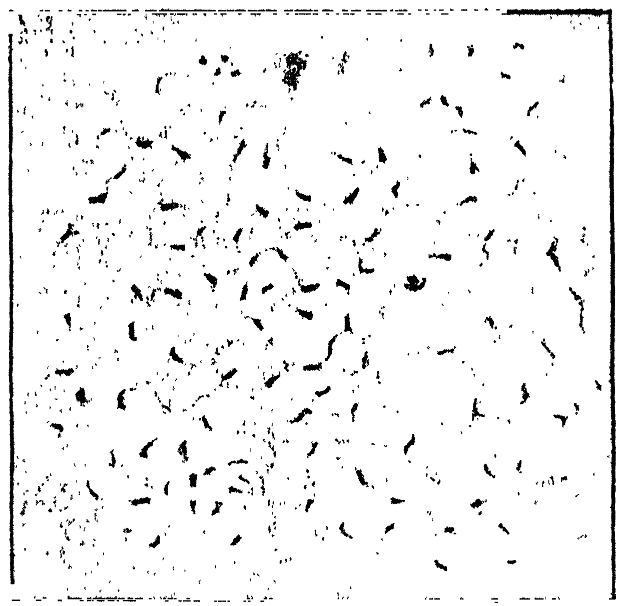

Fig. 53—Bacillus pestis in the human blood.

Horses, goats, cows and sheep are immune against even artificial inoculation according to Haffkine. The German Plague Commission has found that pigeons, fowls, geese and pigs are absolutely refractory, and dogs almost so. The opinion is divided as to whether cats are susceptible to plague, but certainly they are refractory.

Rats.—There are two chief varieties of rats in India, which are concerned in spreading the disease. These are *Mus decumanus* and *Mus rattus*. The former has a longer and sharper snout, smaller ears, less bristly fur and a more

Fig. 54—*Mus decumanus*. The Sewer Rat.

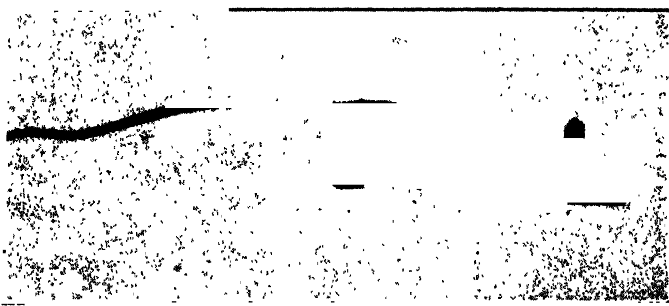

Fig. 55—*Mus rattus*. The House Rat.

hairy bi-coloured tail, the dorsal surface of which is darker than the ventral, and is found only in Bombay and some other seaport towns in India. In Bombay it inhabits stables, outhouses and sewers, and enters houses only for food. The latter, *Mus rattus*, is of small size and of dark colour. The body is shorter than the tail and the ears are pointed and large. It is found in all the villages in India, and is a true companion of man, inasmuch as it lives and breeds in human dwellings. It lives in cupboards and under boxes, and makes burrows in the muddy floors and walls of huts in Indian

villages. It breeds and multiplies with great rapidity, feeding upon the grain and other materials stored in the house. It is mostly concerned in spreading plague in villages, and it is a direct cause of human plague in India. Cases among men generally occur from a week to a fortnight after rats die of plague.

Fleas.—Simond, in 1897, advanced the theory that plague was transmitted from rat to man by fleas. This theory was developed by J. Ashburton Thompson and others, and conclusively proved by the Indian Plague Commission. The fleas that are concerned in conveying the disease are *Pulex cheopis* or *Xenopsylla cheopis* (Indian rat flea), *Ceratophyllus fasciatus* and *Pulex irritans*, the human flea; and other fleas infecting dogs and cats may also carry the plague.

Fig. 56—Male Pulex Cheopis.

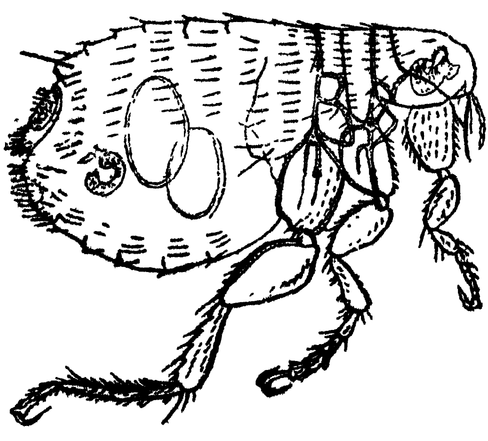

Fig. 57—Female Pulex Cheopis.

Fleas are flat, wingless insects and pass through four stages, *viz.*, embryo, larva, pupa and imago. The adult female flea deposits her eggs, about 12 in number, among the hair or fur of the host animal, but they fall freely to the ground as they are not fastened together. Sometimes, she lays her eggs in dust and dirt. These are oval, whitish, smooth and about half a millimeter long, and hatch out in 50 hours or more. The larvæ are slender, legless, cylindrical creatures, whitish or yellowish in colour, each having a head and 13 segments. The larvæ feed on almost any kind of refuse. They usually crawl into cracks and crevices in the floors and walls of the

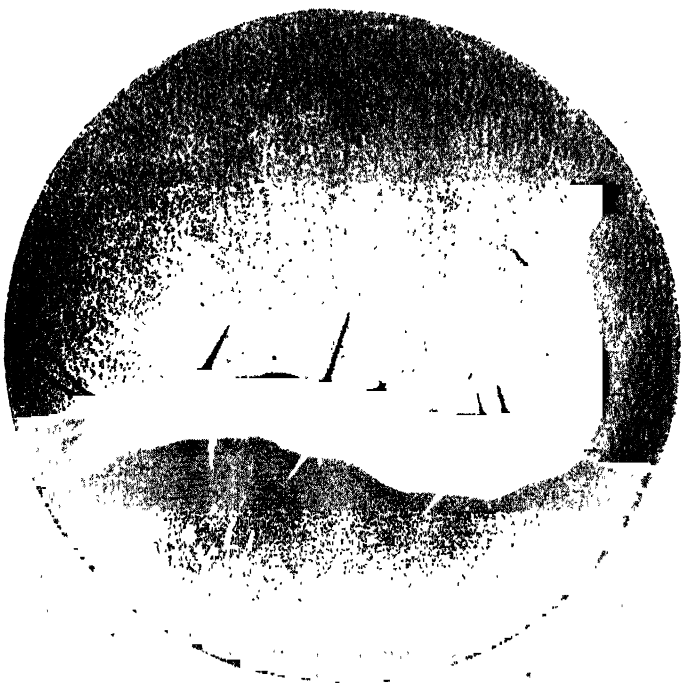

Fig. 58—Larva of a Flea.

houses. They live about 7 days and then spin cocoons in which they change to the pupal stage. The adult flea develops from the cocoon stage in from 5 to 8 days. It has a hard

and strongly chitinized body, and its mouth parts resemble somewhat those of the mosquitoes.

These fleas cannot fly higher than 6 inches above the ground and avoid light. Fleas do not vary much in size. They are mostly about 2 to 3 millimeters long. Both the male and the female are capable of biting, and thus transmit infection. They do prefer certain hosts, but are not very particular in this regard, specially when they are very hungry, and that is the reason why they are dangerous so far as plague and other infections are concerned. The rat flea thus leaves the plague-stricken rat after its death, and being hungry attacks human beings in the house, as it does not find its own host, *viz.*, the rat ; for rats leave the house when they find that some of their companions die of this disease. The plague bacilli multiply in the stomach of the flea, and remain alive for seven or eight days, and are passed out in the dejecta and deposited on the human skin near the puncture when the flea bites a man. Inoculation then takes place, when the skin is scratched with the finger nails to allay irritation of the bite. The bacilli also grow in masses in the flea's œsophagus, and block the entrance of the stomach. The starved flea makes violent efforts to get more blood, and the œsophageal contents regurgitate thereby infecting through the skin lesion the healthy person whose blood the flea is trying to suck. The bacilli thus inoculated, are carried by the lymphatic vessels of the skin to the lymphatic glands usually of the groins or armpits, as the legs and arms are most likely to be bitten by rat fleas. The people, who walk about in the houses barefooted, and who sleep on the floor not well protected with sufficient clothing, become the victims of infected fleas.

The pneumonic type of plague is contracted by the inhalation of dust containing the organism or by the direct inhalation of the germs contained in the sputum sprayed out into the air by the patient's cough. In some cases the bacillus infects the system through the tonsils and the mucous

membrane of the mouth, when the resulting bubo forms in the submaxillary region, or at the angle of the lower jaw.

CONDITIONS FAVOURING THE SPREAD OF PLAGUE.

The circumstances that favour the spread of plague are filth, overcrowding, poverty and a lowered tone of the general health. Owing to poverty and the filthy habits of the people of allowing grain and other eatables to lie about in dark ill-ventilated houses composed of one or two rooms in many cases and also allowing cattle, goats, hens and other domestic animals to live among them, rats are always found inhabiting such houses, which lead to the spread of plague, if once the locality is infected.

The plague is usually carried from house to house in a town or village by means of infected rats ; but they do not carry infection from one locality to another, as rats are not found to be migratory in their habits, though they may be carried from one place to another in merchandise, *e.g.*, grain, cotton, hay, furniture, etc., but on the other hand, infected fleas are carried by persons in their clothes or other belongings while going from an infected place to an uninfected area, where these fleas inoculate rats, their natural hosts, if they find them. Thus, the plague first breaks out among rats, and then later on among men.

The disease is most common among young people of both sexes who are in the prime of life, but women are more apt to be attacked than men, since, owing to their habit of remaining indoors they are more liable to be bitten by rat fleas. Infants and young children appear to enjoy a certain degree of immunity. The disease generally occurs during the cold weather. In India plague usually subsides during the hottest weather, and recrudesces with the onset of the cold season. Rainfall in defect of the normal is inimical to plague, while excessive rainfall is favourable to its spread. Humidity at certain seasons of the year in excess of the normal is beneficial to the rat flea

in all the stages of its development, and a flea population in excess of the normal appears to be essential to plague epidemics of more than average intensity.

VARIETIES OF PLAGUE.

There are three chief varieties of plague, *viz.*, the bubonic, pneumonic, and septicæmic. The incubation period of the bubonic variety varies from two to seven days, but that of the pneumonic and septicæmic types is much shorter and in some cases even less than 24 hours. Death frequently takes place within 48 hours of the onset of the symptoms. A fatal result is, as a rule, rare after the 8th day,

PROPHYLAXIS.

Isolation of the sick, placing the people of the infected locality under quarantine and their surveillance for ten days, specially when they had travelled from one place to another either by rail or by road, were the chief measures adopted by the Government in the beginning of the plague, but they had to be given up owing to the apathy of the people towards them. The principal preventive measures that are now adopted are a campaign against rats, evacuation, disinfection and inoculation.

A Campaign against Rats.—Plague is primarily a disease of rats, and it can safely be deduced that there would be no plague, if there were no causes existing, which would bring about association of rats with men. It is, therefore, very necessary to fight against rats, if plague has to be eradicated from a locality. This should be carried out by rendering the dwellings rat-proof and rat-free and by destroying or trapping rats.

In designing rat-proof dwellings it should be borne in mind that the *Mus rattus* cannot jump higher than 2½ feet, cannot circumvent a horizontal ledge of 9 inches, provided this be smooth on the undersurface, and cannot live on dry grain without some water to drink.

The dwellings should have the basement, floors and roofs

made of such concrete material as would not harbour rats. The lower parts of the doors and windows, specially on the ground-floor, should be reinforced with strong iron or tin sheets to keep them from gnawing through. The open mouths of the house drains should be surrounded with concrete and screened with strong galvanized iron netting.

Rat holes should be closed with a mixture of cement, sand and broken glass, or sharp bits of crockery, bricks, and stone. Shops, warehouses, granaries, restaurants, markets and stables should be separated from human habitations.

The people should learn to keep their rooms clean and tidy, and should not throw waste food material and grains anywhere in the premises of houses or in streets, where rats might easily reach them. They should take proper steps to collect and dispose of house refuse. They should not store grains and corns in earthen *garahs* or sack-cloth bales, but in iron or tin pots or *pacca* masonry-built receptacles, so that rats may not have access to them.

In a country like India it will take many years to carry out these measures to completion, and so steps should be taken to destroy all the rats by using poison or disseminating bacterial disease among them. Phosphorus mixed with sugar and wheat flour is a poison which is commonly used to kill rats throughout the world but, from the interesting observations carried out in Poona, Dr. Chitre and Major Kunhardt, I.M.S., have proved that barium carbonate is by far the most efficient. It is cheap, fatal to rats in a dose of 1½ grains, and comparatively harmless to men and domestic animals. It is also one of the very few poisons that the rats fail to detect. Rats prefer the food grain, which forms the staple food of the human population of their place of origin. Hence barium carbonate should be mixed into dough with freshly ground flour made from the grain, which forms the staple food of the people of the locality, where rats are to be killed. One pound of barium carbonate should be mixed with 3 pounds of flour in an

enamelled basin, and the mixture with the addition of sufficient water should be made into a thick paste to be divided into 2,400 round baits of uniform size, each containing 3 grains of the poison. The baits should be set towards night in such places as are accessible to rats and not readily accessible to children or domestic animals. All sources of food supply usually available for rats should be kept covered up so as to make them hungry. About 20 baits are sufficient for every thousand cubic feet of space. The baits are only attractive to rats when fresh. Hence they should be made fresh each day, or at most every second day. When barium carbonate is not available, the Punjab Rat Exterminator, which is equally efficient, may be used ; 3 grains of the exterminator is fatal to a *Mus rattus* of average size.

Rats should also be attacked in their hiding burrows by fumigation with carbon monoxide, carbon dioxide, sulphur dioxide or hydrocyanic acid gas or potassium chlorate candles. In 1914 Lane devised a *neem-batti* (candle) for the destruction of the rats and their fleas in the burrows. It is prepared at the Punjab Plague Equipment Depôt, Jullundhur in the following manner :—

Potassium chlorate 2 drachms, Potassium nitrate $1\frac{1}{2}$ drachms, and sulphur 2 drachms are powdered together and mixed with 5 drachms of oil (castor oil, *Taramira*- mustard, etc.) to form a paste, to which a drachm of chilli powder and a handful of crushed dried leaves of *Neem* (*Azadirachta indica*) are added. A wick of about 9 inches, made of thick cloth (*khaddar*), is soaked in a saturated solution of potassium chlorate. The wick is covered over with the paste leaving exposed about an inch at one end. It is then encased in cloth, over which a thick paper is wrapped.

To use a *neem batti* all openings except one opening of the burrow are closed, the *batti* is then ignited and introduced in the open hole, which is then similarly closed. Rats and their fleas are killed in 5 minutes in the burrows varying from

3 inches to 3 feet in length.[1] But this method of reducing the number of rats in a locality has been found quite impracticable for want of co-operation on the part of the people, for a large majority of them, owing to their religious beliefs, will not assist in taking away lives of insects and animals, however destructive they may be to life and property.

Rats have been found very resistant to bacterial infection; and so an effort to destroy them completely by spreading some infectious disease among them has not so far met with any success.

Lastly, the number of rats should be kept down by advising the people to keep cats or to trap them alive and to send them to depôts, where they should be subsequently destroyed. It should be borne in mind that the same kind of the trap should not be used in one locality for more than two or three nights. Another method of reducing their number is to kill the captured females and to set free the males. The number of females being thus reduced the males fight for the possession of their mates, and both males and females perish in the struggle.

Dead rats found in the house should not be handled or thrown about in gullies or streets, but must be burnt on the very spot.

It is also necessary to examine bacteriologically trapped or killed rats to find out whether they are infected by plague and to find out the locality where plague is raging.

As fleas are the carriers of the disease-germs, attempts should be made to destroy them as well. The larvæ should be attacked in the cracks and crevices of the floor by sprinkling a thin coating of naphthalene on the floor, and leaving the room tightly closed overnight. In the morning the naphthalene may be swept up and what remains used again. Adult fleas are generally killed by the same poisons as are used to kill their hosts. Formalin, pesterine, mercuric chloride,

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1. C. D. Tiwari and R. B. Lal, Ind. Med. Gaz., July, 1925, p. 310.

tincture of green soap, chloroform and ether are efficient poisons for killing fleas. The gases employed are CS_2, SO_2, and HCN.

Another method of destroying fleas, as suggested by Lieutenant-Colonel D. T. Lane, I.M.S., Chief Plague Officer of the Punjab, is by using cresol vapour. The method of using it is as follows :—

Put two ounces of cresol on smouldering fire of four or five cowdung cakes in a cup of iron in a closed room, or put a cup containing an ounce of cresol over the fire of any material which is not in flame. In the former case the cresol will be completely burned in two hours ; and in the latter case it will vaporize in an hour. The advantage of using cresol is that it is fatal to fleas, but harmless to men and animals. It should be remembered that cresol to be efficacious should be vaporized and not ignited.

To avoid the bites of fleas it is much better that people should anoint their bodies, especially the exposed parts, such as the arms, legs and necks, with mustard oil as is the custom in Bengal. This should be done at least two or three times in a day. Kerosene oil and citronella oil may be mixed with mustard oil.

Evacuation.—As soon as rats are found dying in a house, in a *mohalla* or in a village, all the people living in that house, *mohalla* or village should at once evacuate their houses and live in camps in the open. The rats should then be destroyed, and the houses should afterwards be thoroughly disinfected chiefly by pesterine ; but the people should not go to live with their friends in uninfected villages or towns, for thereby those places are liable to be infected through their agency. The people should not be allowed to go back to their houses to fetch any articles, after they have once left them, as they are liable to be bitten by infected fleas there, and thus carry infection to the camps. As far as practicable, Municipalities of towns and District Boards in rural areas should provide the people with materials free or at nominal costs,

with which they can build huts in the open outside the town or village. There should also be proper arrangement for a pure water-supply, scavenging and *chowkidary*, as well as for lighting at night.

Fleas are generally carried in the clothes, bedding and such other articles when carried from one village to another, and are thus likely to convey infection. They should, therefore, be unfolded and exposed to the sun for an hour or so on some hot sandy place away from trees or houses outside the village, before persons carrying such clothes are allowed to enter the village. The fleas, if there are any, will thus be killed by this exposure, and then there will be no danger of conveying infection to the inhabitants of the village.

Disinfection.—The plague-infected house should be disinfected by cyllin, formalin or pesterine, and should be whitewashed before it is re-occupied by the inmates. In this connection it may be mentioned that the Plague Commission has shown that the floors of crow-dung contaminated with *Bacillus Pestis* do not remain infective for more than 48 hours and that the floors of "chunam" cease to be infective in 24 hours.

All articles used by the patient should be burnt, if possible. If not, they should be thoroughly disinfected by steam after being first well soaked in a disinfecting solution. Discharges, such as urine etc., should be burnt. Dead bodies should be burnt, where possible; but they should not be disposed of, if a medical certificate as to the cause of death is not forthcoming.

Inoculation.—The last but not the least important measure is inoculation by Haffkine's vaccine made from dead plague cultures to which 5 per cent. carbolic acid is added. The vaccine is prepared under the direct supervision of experts in Parel Laboratory at Bombay and sent out in hermetically sealed glass bottles. Each bottle contains 20 cubic centimeters of the vaccine, sufficient for 5 full doses. Inoculation reduces the incidence of plague cases, diminishes

mortality to a very great extent, and instils into the inoculated persons that confidence which is so very necessary in averting a panic. It confers immunity for from 6 months to a year,

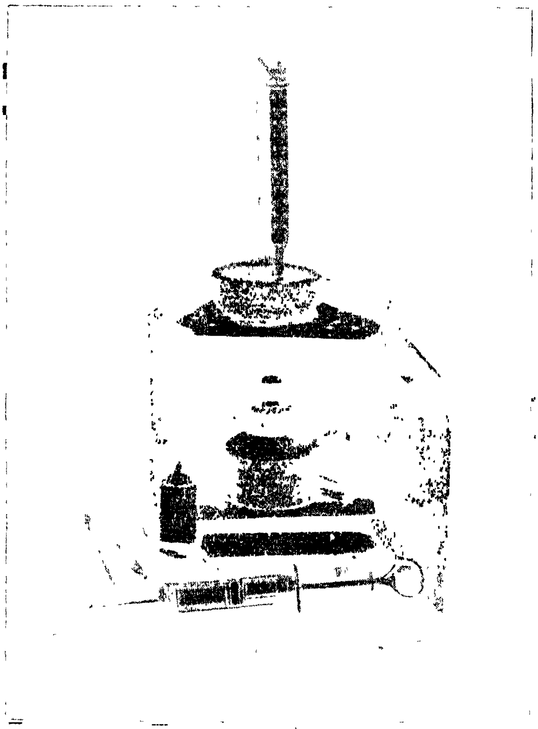

Fig. 59—Inoculation Outfit.

and, therefore, it is much better to be inoculated at every season of the plague. Frequent inoculations are not known to have caused any harm.

Method of Inoculation.—It is always best to collect as many men as possible before the operation of inoculation is started. Those, who hesitated in the beginning, might volunteer to be inoculated when they found that the operation was

simple, easy and quite painless. Before starting the operation, one should provide oneself with an inoculation outfit consisting of two 20 c.c. Roux syringes, Kapadia's lamp, a stand, an aluminium dish, a thermometer, a pair of dissecting forceps, pure carbolic acid, vaseline and some enamelled bowls.

Kapadia's lamp should be lighted, and vaseline, olive or cocoanut oil should be heated in a dish over the lamp after the thermometer is adjusted in the vaseline or oil. The needles should then be put in the dish after having seen that their Points are sharp and clean.

After ascertaining that the syringe is air-tight, it should be filled with the heated vaseline when its temperature has reached 90° C. and again emptied into the pot, so that moisture may be got rid of. Moisture at temperatures above 100° C. is immediately converted into steam, and this causes the vaseline to crackle and splash and may, perhaps, fracture or burst the glass barrel.

The syringe should again be completely filled and emptied twice with the hot vaseline when the temperature has reached 160° C. The syringe is now completely sterilized. A temperature higher than 160° C. injures the india-rubber plunger and a temperature lower than 160° C. is not so efficient in effecting sterilization..

Pick up a needle from the dish with a pair of dissecting forceps, and adjust it firmly to the nozzle of the syringe.

Draw up and eject the hot vaseline from the syringe with the needle *in situ*. The syringe may now be carefully laid on one side, preferably supported on the lid of the syringe box, and allowed to cool. The needle should, under no circumstances, be allowed to come into contact with any article or surface.

A bottle of anti-plague vaccine is then taken in hand. The neck should be examined for any cracks or flaws. Faulty bottles should never be used but rejected, and the contents thrown out. The bottle should be well shaken, so that the

sediment at the bottom should be well mixed up. This sediment consists of the dead bacteria, and is, therefore, an essential part of the vaccine.

To open the bottle, the neck should be held in a flame, and a little jerk should be given to the fluid, when the neck will crack, if it has become hot. The tip may then be knocked off by a sharp blow from a pair of sterilized forceps.

Now take up the syringe, draw into it a small quantity of hot vaseline, and again eject it while the needle is still hot: draw into the syringe two or three cubic centimeters of the anti-plague vaccine. Place the bottle on its side on the table. Then draw out the piston of the syringe to its full extent, and shake up the small quantity of the vaccine within the barrel of the syringe. Eject the contents of the syringe. This is done to get rid of some of the excess of vaseline which adheres to the interior of the syringe.

Again dip the needle in the hot vaseline, pass the point of the needle through the flame, and then fill up the syringe. Get rid of excess of air by adjusting the piston. Note the graduation marks on the shaft of the piston, and read off four marks counting from the outside of the barrel of the syringe. Screw up the disc to the point noted. The syringe is now ready to deliver 4 cubic centimeters or one dose of the vaccine.

The inoculation is done at the insertion of the deltoid muscle on the left arm. The skin should be well scrubbed with 1 in 20 carbolic lotion. The dose should then be injected by entering the needle only in the subcutaneous tissue, and care should be taken that it does not enter the muscles, big vessels, or nerves. A pad of cotton-wool soaked in 1 in 20 carbolic lotion should be applied for a few seconds over the puncture. The needle of the syringe should be sterilized by dipping it into the hot vaseline every time the inoculation is performed. After all the inoculations have been finished, the syringe should be thoroughly washed out with 1 in 20 carbolic lotion, and the needle should be covered with vaseline.

The following are the doses to be given to persons in good health at various ages, the usual adult dose being 4 c.c. :—

0.2 c.c. or 1/20 of full dose for an infant of from 10 days to 1 year.
0.8 c.c. or 1/5 of full dose for an infant of one to two years.
1.6 c.c. or 2/5 of full dose for a child of two to five years.
2.4 c.c. or 3/5 of full dose for a boy of six to eleven years.
3.2 c.c. or 4/5 of full dose for a boy between twelve and fifteen years.
4.0 c.c. or full dose for a person between sixteen and fifty years.

N.B.—3 c.c. may be given as a full dose if the vaccine is to be used within three months of its preparation.

Persons over 50 years should be given 1/10th less for each decade above that age. Women of all ages over 14 years should be given 1/10th less than men of corresponding ages. Pregnant women may be inoculated up to the end of the 7th month with the usual dose. After that month the dose should be given in two instalments separated by an interval of a week or so. Miscarriage has never been known to result from inoculation, but inoculation should be insisted on pregnant women as plague among parturient women is ordinarily fatal.

The symptoms caused by inoculation commence, as a rule, in three to five hours, and consist chiefly of a swelling and pain at the seat of inoculation and of a rise of temperature. The arm should be kept at rest in a sling as any kind of movement enhances pain. Alcohol should be avoided after inoculation. There is a general discomfort and slight malaise accompanying fever, which subsides after 24 to 36 hours, but the pain lasts for 3 to 4 days and disappears gradually, though some induration remains for some time at the seat of inoculation. In some cases there is no fever. The presence or absence of temperature is no criterion to the protection acquired by inoculation.

CHAPTER XVIII.

THE HOUSE-FLY AND THE DISEASES CONVEYED BY IT.

The House-fly.—The house-fly, or the *Musca domestica*, as called by entomologists, belongs to the family muscidæ of the order Diptera. It is found everywhere in the world, though it is more frequent in warm climates than in

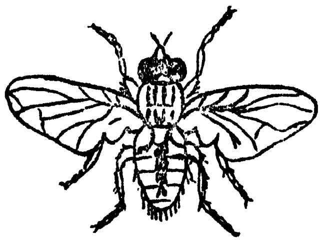

Fig. 60—House-Fly.

cold ones. The house-fly breeds chiefly in stable manure, but in India it has been found to breed in human excreta, excrement of dogs, cowdung, decaying and fermenting vegetable and animal matter, in carcasses and in putrefying filth.

The female hibernates in dark corners and roofs of the houses in winter. It lays from 4 to 6 batches of eggs with the setting in of warm weather, and at each time deposits from 100 to 150 eggs. The eggs are sausage-shaped with one end sharp, and measure about 1.5 mm. in length and 0.3 mm. in their greatest diameter. They are pure white in colour, and present a highly polished surface due to the clear viscous substance with which they are coated. They hatch into larvæ or maggots from eight to twenty-four hours in hot weather. The larva is a white, slender, footless creature, measures about 2 mm. in length, has a sharp anterior end and a blunt posterior end, and possesses a pair of breathing holes or spiracles. It eats voraciously and is capable of passing through a thickness of soil of over three feet in order to reach the surface. It grows rapidly, and under the most favourable

conditions of warmth and moisture attains its fully developed size of 6 to 9 mm. in length in four or five days. It then becomes a pupa or chrysalis in a hard brown barrel-shaped case, the puparium, which requires warmth and dryness for its development. During this stage many of its organs undergo disintegration, and are re-formed ; and in the course of 3 or 5 days the pupal case opens, and the adult lively fly appears, which seeks sunlight as well as the companionship of man. After leaving the pupa case the fly stretches its wings, the integument of the body hardens, and within an hour or two takes wing.

Flies become sexually mature in a week or ten days, and are able to deposit eggs four days after mating. They travel with the wind, and are known to have travelled half a mile in an hour. They are to be found throughout the year in tropical countries, but they perish or their larvæ are killed during the hottest and driest months in dry countries. In temperate regions flies are most prevalent in spring and autumn. They die off in cold and extreme wetness, but a few, that hide themselves in warm, secluded places, remain alive during the winter. Flies may live from six weeks to four months during a favourable season. At the end of the season they are mostly affected by a fungus disease caused by *Epsuma muscæ.*

The mouth parts of the house-fly are so constructed that it can only suck in liquid food. Hence it first dissolves solid food, such as sugar, by depositing some saliva on it, and then sucks up the sugary solution. It very frequently regurgitates its food in a spherical drop, which it generally re-absorbs.

The Mode of Carrying Disease.—Unlike fleas and mosquitoes the house-flies do not bite, and so cannot convey disease by direct inoculation into the circulatory system, nor do the specific micro-organisms undergo developmental changes in their alimentary canal. They, however, transmit diseases by mechanically transferring infection on their legs, wings and body or by sucking infected material into the crop, and then contaminating foodstuffs, etc., with their vomit or dejecta,

The diseases that are thus conveyed by house-flies are enteric fevers, cholera, infantile diarrhœa, amœbic dysentery, and gangosa. Ophthalmia, particularly in hot countries, is spread through the agency of flies, which carry the Koch-Weeks bacillus and the gonococcus from eye to eye.[1] Tuberculosis, leprosy, diphtheria, measles, small-pox, erysipelas, anthrax, glanders and some skin affections may also be carried by flies.

It should be mentioned that the method of conveying infection by the alimentary canal is more important than the carriage of infection on the surface of the body, inasmuch as many pathogenic organisms would soon die from desiccation on the appendages of the fly, and, at any rate, the number so conveyed is small compared to those contained in its crop or intestine. The following table, taken from Graham Smith's report, summarises the result of his experiments on the length of time after which various bacilli can be recovered from the outside and inside of flies fed on infected material.[1]

Table showing the longest period after which organisms were recovered from flies fed on Cultures (Graham Smith).[1]

Organisms.	Legs.	Wings.	Head.	Crop.	Gut.	Fæces.
B. typhosus ...	......	......	......	......	6 days	2 days
B. enteritidis ...	7 days	......	7 days	8 days	7 days	......
B. tuberculosis (culture).	......	......	......	3 days	16 days	13 days
B. tuberculosis (sputum).	......	......	......	......	7 days	5 days
Yeast ...	2½ hrs.	2½ hrs.	2½ hrs.	2 days	3 days	2 days
B. diphtheriæ ...	5 hrs.	5 hrs.	5 days	7 days	5 days	2 days
B. anthracis (no spore).	2 days	......	4 days	5 days	3 days	2 days
B. choleræ ...	30 hrs.	5 hrs.	5 hrs.	2 days	2 days	30 hrs.
B. prodigiosus ...	8 days	12 hrs.	11 days	5 days	17 days	6 days
Anthrax spores...	20 days	20 days	20 days	13 days	20 days	13 days

1. C. J. Martin, Brit. Med. Jour., Jan. 4, 1913, p. 3.

During the last Great War Wenyon and Connor observed while experimenting with house-flies that cysts of E. histolytica could be found in the fæces of flies twenty-four hours after a meal on infected fæces, and in one case cycts of E. coli were found so long as forty-eight hours after the last feed.[1]

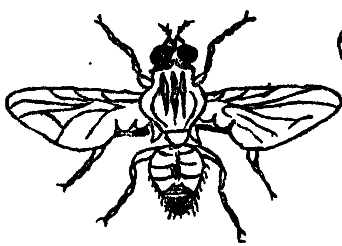

Fig. 61—Lesser House-Fly.

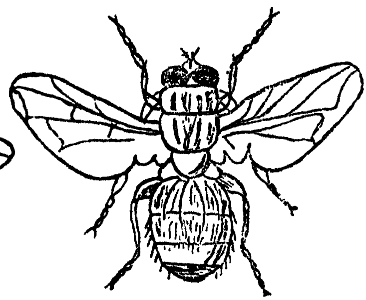

Fig. 62—Screw-Worm Fly.

Another species of house-frequenting flies is known as *Fannia canicularis* or "the lesser house-fly." It resembles the common house-fly, but is smaller in size and appears earlier in the spring. The female lays eggs in decaying vegetable and animal matter and sometimes in fæces. The larvæ are broad, flattened and brown in colour, having branched processes on the segments. They are normally found in decayed vegetable and rotten fruit, by means of which they sometimes enter the human alimentary canal. The eggs may also be deposited in or near the anus of people using filthy latrines, whence the larvæ enter the large intestine.

The larvæ or maggots of some species of flies infest the human body and produce definite troubles which are grouped under the term "myiasis". They may penetrate under the skin and cause subcutaneous troubles. The eggs may be deposited into putrefying open wounds, whence the larvæ burrow into the tissues and cause great destruction even by attacking cartilage and bone. In some cases they may enter

1. Official History of the War, Med. Services, Hygiene of the War, Vol. II, p. 302.

the natural openings of the body. If they penetrate the nose or ears, they may go deeper, penetrate the brain substance, and may cause death.

According to Patton[1] the flies capable of producing myiasis in India belong to two important families, the *muscidæ* and the *sarcophagidæ*, the former being again split into two small groups, the *muscinæ* and the *Calliphorinæ*. The two genera of flies belonging to the subfamily, *Muscinæ* are *Lucilia* and *Chrysomyia*. *Lucilia* is a green or blue fly having a very bristly thorax, while *Chrysomyia* has very few bristles but a dense covering of fine hairs and abdominal bands. *Chrysomyia bezziana* and *Chrysomyia megacephala* (*dux*) are the two important blow flies of India. The former lays eggs in living tissues, which hatch out in twenty-eight hours. The latter breeds in dead bodies and decaying organic matter, though it occasionally deposits eggs on the diseased tissues, such as sores, wounds, etc., on the bodies of animals.

The *Calliphorinæ* or Blow flies are large green or blue insects often with a characteristic brassy sheen. Of these the

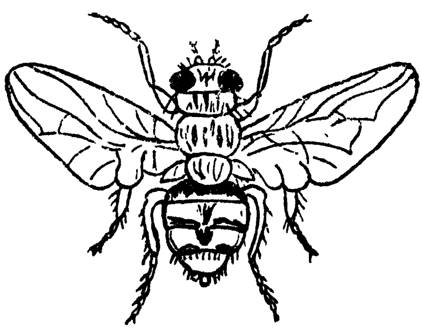

Fig. 63—Blow Fly or Blue-Bottle Fly.

most important is *Calliphora vomitoria*, commonly called, "blue bottle fly" or "meat fly". It lays eggs in fresh or decaying animal tissues, and is, therefore, a great source of

1. Ind. Jour. of Medical Research, Vol. IX, 1921-22, p. 685, *et sequor*.

nuisance in cases of large open wounds. The species of *Sarcophagidæ* or flesh flies which breed in wounds or natural cavities of living bodies are large grey flies with dark stripes on the thorax and checkered markings on the abdomen.

Biting Flies.—The species of flies belonging to the family, *Muscidæ*, which feed by sucking the blood of men and animals, are called biting flies. As a result of their feeding habits they are mostly responsible for transmitting certain diseases by inoculating the parasites directly into the system by piercing the skin with their mouth parts. Both males and females have equally developed the blood-sucking habit. In the majority of these biting flies the proboscis is slender, rigid and tapering, adapted for piercing. The most important of these insects belong to the genus *Stomoxys* (stable-flies) and the genus *Glossina* (tse-tse flies).

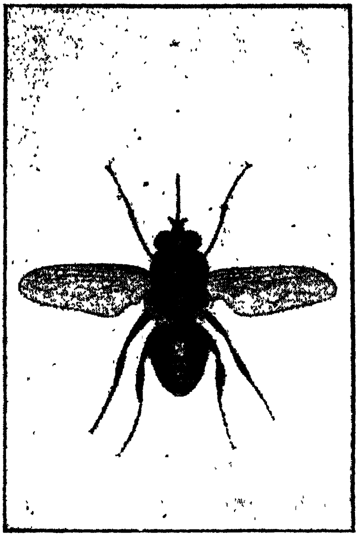

Fig. 64—Tse-tse Fly.

The commonest species of the genus *Stomoxys* is *Stomoxys calcitrans*, the stable-fly. It is widely distributed all over the world, and is generally found in stables, houses and in the open in the vicinity of horses and cattle. It bites all classes of mammals and is a great annoyance to horses and cattle in the late summer and autumn. It sometimes bites men, and is implicated in conveying anthrax, and possibly infantile paralysis. It is also incriminated in the transmission of " surra ".

In general appearance the stable-fly closely resembles the common house-fly, but it may be easily distinguished by the

projecting shining-black proboscis and by the head pointing upwards and the wings being widely divergent when resting on a wall. The female usually breeds in moist, fermenting heaps of grass, decaying vegetable matter and in cow- or horse-dung. The eggs are about one mm. in length, white in colour, and are shaped like a banana, being curved on one side and flat on the other, where there is a deep groove. They hatch into larvæ in two or three days. The larvæ greatly resemble those of the house-fly, and, under favourable conditions, become mature and develop into pupæ in about two to three weeks. The pupæ are olive-shaped, chestnut-coloured and about 5 to 5.5 mm. in length. The pupal stage lasts from 6 to 10 days under favourable conditions of warmth and moisture, but may be considerably prolonged by cold weather.

The species belonging to the genus Glossina (tse-tse flies) are narrow bodied, elongate, dark brown or yellowish brown flies, varying from 6 or 8 to 13.5 mm. in length. They can be recognised from other flies by the thick proboscis projecting horizontally in front of the head and by the wings folded flat over one another when at rest. These flies are confined to Africa and the south-western corner of Arabia, and are generally found in shady, bushy places near water-courses. The most important of this species is *Glossina palpalis*, which is concerned in transmitting the disease called sleeping sickness or trypanosomiasis. These flies are diurnal in their habits and *G. palpalis* bites particularly about midday.

Tse-tse flies do not lay eggs as do others of the family *muscidæ*, but the eggs hatch and develop into larvæ within the body, the female giving birth to a single larva, followed by another after 14 to 15 days. The unborn larva almost completely fills the abdomen of the mother. The larva is a yellowish ovoid creature, with two small hooks at the anterior end and a pair of respiratory protuberances at the posterior end. Immediately after extrusion it crawls and hides itself in a shaded place near the roots of trees. In a few

hours it becomes a jet black pupa, from which the imago emerges in about 4 to 9 weeks.

Prevention and Control of Flies.—Towards the close of the breeding season most of the flies are carried away by a fungus disease, and centipedes and beetles also destroy a large number of them ; however, owing to their great fecundity, flies can never be controlled and prevented, unless the following measures are taken against their breeding places as also against the adult flies :—

1. Stables must be kept clean, and there should be no crevices in their walls or floors, which should be made *pacca* with concrete, and should be washed daily with phenyle or some other disinfectant.

2. Manure should not be allowed to collect in open heaps, but must be kept in tightly fitting closed barrels and should be incinerated on the spot or carried for disposal far away from cities and towns.

3. House rubbish and refuse should be collected in dust-bins with closely fitting covers, but should not be allowed to lie near the premises of houses.

4. Latrines should be kept scrupulously clean, and human excreta should not be allowed to remain for any length of time in privy pans or *gamlas* which should at once be emptied into iron receptacles with tightly fitting lids. Kerosene oil should be used in latrines to destroy the eggs of parasitic intestinal worms and larvæ of flies.

5. In famine camps and fairs, trenches in which night-soil is buried, should be sufficiently deep and should be well covered with dry earth, so that if eggs are laid underneath the earth by any chance, they may not be able to emerge therefrom.

6. To destroy flies latrine screens, bushes, straw, etc., should be sprayed with water containing a little sugar, and one ounce of sodium arsenite to the gallon. Arsenious acid with sodium carbonate or washing soda may be used.

7. Doors and windows should be screened to keep flies away.

8. "Tangle-foot" papers (fly papers) coated with a sticky mixture of various forms should be used to catch flies in houses. Sticky mixtures can be prepared by heating 4 pints of castor oil and 9½ lbs. of crushed and powdered resin until the resin is dissolved without boiling it, or by heating 5 parts of raw linseed oil and 12 parts of powdered resin.

9. Flies are generally seen clustered together in large numbers and resting at night on a piece of cord or string hanging vertically in a room. Hence they can be destroyed by applying a torch of paper or cotton wool soaked in methylated spirit to such clusters. Or a saucer containing a little petrol may be held under the cluster, when the flies, becoming stupefied, will fall into the liquid and perish.

10. Flies being thirsty insects are always attracted towards water or liquid; hence if all sorts of liquids are removed from a room and a 2 per cent. solution of formaldehyde is placed in saucers containing some milk and sugar, flies will drink from this liquid, and will be killed in a short time. Arsenic, potassium bichromate or infusion of quasia may be used instead of formaldehyde.

11. Fly traps of various designs are used for destroying flies. A Japanese clock-work, mechanical trap is very ingenious and effective. It consists of a slowly revolving cylinder coated with gum. The flies are trapped by a ledge projecting on the cylinder and are diverted into a box underneath. During the last Great War Lieut.-Colonel Andrew Balfour[1] devised a fly trap to be used for the field. The flies were attracted by baits of various kinds, such as milk, lentil paste, cheese, tea leaves, jam, etc., and entered by a narrow slit in the side. Once inside they could not go out, and could then be killed by fumigation.

1. Official History of the War, Med. Services, Hygiene of the War, Vol. II, p. 319.

CHAPTER XIX.

CHOLERA (ASIATIC CHOLERA), DYSENTERY, TYPHOID FEVER, TUBERCULOSIS AND TRYPANOSOMIASIS.

CHOLERA.

THIS is a disease particularly of man, and for several centuries has been known to be endemic in the delta of the Ganges in the lower part of Bengal, from where it has spread in an epidemic form to other parts of India and in a pandemic form over wide areas of the earth's surface. In all epidemic and pandemic outbreaks cholera has always travelled along the routes of trade, such as caravan routes, railways, navigable rivers and sea-route. Again, the big outbreaks have always been traced to large fairs and gatherings and subsequent dispersions of pilgrims, as at Hardwar and Mecca. Thus it has spread to Afghanistan, Persia, Turkey, Russia and other countries of Europe, America, China and Japan. There is hardly any country in the world which has not been visited by cholera.

The incubation period of cholera is very short, a few hours to 5 days. One attack confers a mild grade of immunity, which is not lasting.

Aetiology.—Koch discovered the Comma bacillus or the cholera vibrio as the specific micro-organism causing cholera, first in Egypt in 1883, and then in Calcutta in 1884. It was found by him in the intestines and the stools of patients suffering from cholera. It is a very minute organism having the form of a slightly bent rod, which is thicker but not more than about half the length of the Tubercle bacillus. Sometimes it assumes distinctly a cork-screwlike shape. On account of the flagella at one end it is an actively motile organism.

Comma bacilli grow well and luxuriantly between 17° and 40° C. on almost anything,—paste, boiled egg, turnip, cucumber,

cabbage, bread, meat butter and various fruits. They grow best at 30° to 40° C. in alkaline media. Their growth is arrested below 15° C. or above 42° C. and they are killed by a temperature above 50° C. They do not grow well in the absence of oxygen. They cannot grow in acid juices of the stomach and, therefore, there is less danger from ingesting them during active digestion than upon an empty stomach. It is only in the alkaline juices of the intestines that they find favourable food for their growth. It has been found by experiments that cold water taken on an empty stomach passes through the pylorus and enters the intestines quickly, where cholera vibrios, if contained in water, will find a suitable medium to grow, and the person drinking such water will probably get the disease.

Warmth and moisture are favourable for the incidence of the disease, which generally increases in April, reaches the maximum in July and August, and almost subsides in November with the onset of the cold weather.

It affects persons of all ages. Those, who are intemperate, weakened by want of food and live in unhygienic surroundings, are more prone to the disease. It is more common in low-lying localities situated near the banks of the rivers than in dry places at high altitudes.

Modes of Infection.—Cholera is principally a water-borne disease. Water of wells, tanks, canals or rivers gets contaminated on account of bowel discharges of sick patients being thrown in their vicinity, or on account of soiled linen and other articles being washed there. In cities where there is an artificial water-supply, water mains are liable to be contaminated by leaky sewers passing underneath the ground near them. Cholera vibrios are capable of living and multiplying in water, and persons using such infected water are liable to get the disease. The Broad Street pump outbreak in London and the Hamburg epidemic are very good instances in favour of the disease being carried through water. Cholera is

known to have been contracted even by using plates and dishes washed in water infected with cholera vibrios.

Vegetables, such as lettuces and radishes, which have been washed in infected water and have been eaten raw may convey the disease.

Flies also play a prominent part in disseminating the disease. They sit on evacuations teeming with cholera germs, and then sit on milk and other articles of diet, to which they transfer these germs, which they carry on their legs, wings and in their mouth parts. People partaking of these infected articles are liable to fall a prey to the disease.

Cholera germs, when dried, die rapidly, and so infection through air is not possible in this case.

Cholera is not highly contagious, for physicians, nurses and other attendants of patients are not affected by the disease, provided they are very clean in their habits, *i.e.*, if they disinfect their hands after handling the patients or their soiled linen, and if they do not take water or food in the same room.

Cholera carriers play an important part in spreading the disease. The cholera vibrios usually disappear from the fæces of patients after the fourth to the fourteenth day, but the healthy persons living in the infected locality may continue passing vibrios for a period of two months, a gall-bladder infection having been established.

Preventive Measures.—1. To control its spread, persons suffering from cholera should at once be isolated to infectious hospitals, where they can be well cared for. It is, therefore, necessary that all cholera cases and even suspected ones should at once be notified.

2. As it is generally carried by pilgrims, they should be thoroughly inspected at the railway stations before they are entrained, and the suspected cases should at once be kept under segregation.

3. As a safe precaution these pilgrims, when they reach their destination, should be kept in segregation for at least

five days or should be kept under surveillance for that period; and should be compelled to report themselves to the medical officer there every morning or evening for five days.

4. The cholera germs are passed in stools, and in some cases in vomits. Hence the stools and vomits should be disinfected with 10 per cent. of formalin, 5 per cent. of carbolic acid, 5 per cent. of cresol, 1 in 100 of cyllin, 1 in 200 of hycol, 3 per cent. of fresh chlorinated lime or equal parts of quick-lime and water, or evaporated to dryness in the *gamla*, into which they are passed, over an ordinary *chula* especially kept for the purpose. They should then be mixed with saw-dust and burnt, or should be buried deep in the earth far away from water-supplies or should be thrown into sewers if there is a drainage system in the town.

5. During the epidemic of cholera private and public latrines should be kept scrupulously clean, and disinfected with phenyle, formalin or milk of lime. If the floor of such latrines be *katcha*, the earth to the depth of four inches must be removed, and fresh, clean earth substituted. The *gamlas* should also be thoroughly disinfected, broken up and buried. If the patient is alive, glazed *gamlas*, four inches in depth, should be provided for the latrine and sick room, and the house sweeper should be furnished with cyllin solution to disinfect each stool before removal. If it is found that the excreta of a patient suffering from cholera are removed without previous disinfection to a filth depôt, the receptacle and carts at such depôt should at once be thoroughly washed out and disinfected with cyllin solution and retarred. The soil of the depôt itself should also be dug to the depth of four inches, and should be covered with a thick layer of quicklime, or mixed with dry grass and burnt.[1]

The surface drain of a street, if it communicates with a drain of the private latrine of a house, in which a cholera case has occurred, should be disinfected daily, as although the

1. *Vide* U. P. Manual of Government Orders, para. 2027.

latrine may not be used by the sufferer, the inmates of the house will probably throw infected matters into it.

6. As soon as the patient dies or recovers, the *pacca* floor and walls of the room occupied by him should be thoroughly disinfected with solutions of formaldehyde, mercuric chloride or cyllin. If the floor is *kutcha*, either the earth should be removed to a depth of four inches, quicklime sprinkled on the ground, and four inches of fresh clean earth substituted, or the floor should be thickly covered with quick-lime or with grass which should be burnt.

7. Upon the death or recovery of the patient, all the clothes worn by him should, if possible, be boiled or disinfected, or if likely to be spoiled by boiling or disinfection, be exposed to the sun for eight hours. When necessary to overcome opposition, compensation may be paid and the clothes burnt. All rags and articles of no value which have come into contact with the patient should be burnt. The *charpoy* upon which the sufferer has been lying, as also any other furniture with which he has come into contact, should also be washed down with a cyllin solution.

8. Utensils, *lotas*, cups, glasses, saucers, dishes, and spoons used by patients should be thoroughly disinfected, and then scalded with boiling water. They should be kept separate as long as the patient is convalescing, or till he is dead.

9. Persons coming into contact with cholera patients should thoroughly disinfect their hands with phenyle or $HgCl_2$ lotion, which should always be kept ready in the sick-room.

10. Persons dying of cholera should be thoroughly cremated, but not near a water-supply. If they have to be buried, they must be buried 6 feet under the ground and away from water-supply.

11. As soon as one or two cases of cholera have occurred in a village or town, the water-supply of that village or town should at once be attended to. The wells should be disinfected with potassium permanganate. If there is a private well in the

compound of a house where a case of cholera has occurred, the well should be disinfected and closed for a month. If, however, further cases occur in the same house, it should be closed for a month after the recovery or death of the last case.

Even the wells of the neighbouring villages and towns should be permanganated, as some people infected with cholera are likely to carry the disease to those places, as they may leave the infected village out of panic, and go to the neighbouring villages.

12. People, as a further precaution, should be advised to drink water after it is boiled. In the absence of boiled water, it is safer to drink water after a grain or two of potassium permanganate is added to a tumbler of water, or it may be acidulated with dilute hydrochloric acid in the proportion of 30 drops to every ounce of water.

13. All kinds of food should be thoroughly cooked and eaten hot, but on no account should be eaten when cold or stale.

14. *Bazaar* sweetmeats should not be eaten under any circumstances, as they are liable to be contaminated with cholera virus by flies owing to their being kept in open saucers in shops.

15. All the articles of food should be well screened, so that flies may not sit on them.

16. Milk should be boiled before use.

17. Butter should be made from boiled milk, and should not be purchased from the *bazaar*.

18. Raw vegetables and fruits should be avoided.

19. Vessels used for cooking and other purposes should be washed with boiled water.

20. People should be temperate in their habits and moderate and regular in their meals, so that they should not suffer from indigestion ; for this is a predisposing cause of the disease, as more attacks of cholera have been noticed after

some feasts. Municipalities should, therefore, not allow caste dinners to be held in streets as is very common in summer at marriage festivities, etc., especially in the Presidency of Bombay.

21. Digestive derangements and diarrhœa should at once be treated by opium, acetate of lead or bismuth.

22. Purgatives should be avoided.

23. Dr. J. W. Tomb,[1] Chief Medical Officer, Asansol Mines Board of Health, recommends that a mixture of volatile oils acts as a prophylactic against cholera, if administered to contacts in one drachm doses in half an ounce of water once or twice daily for one or two days. The mixture is made up as follows:—

R/

Spt. Æther	...	m. 30.
Oleum Caryophyli	...	
Oleum Cajuputi	...	
Oleum Juniperis	...	aa m. 5.
Acidi Sulphur. Aromat.	...	m. 15.

Misce.

By the routine use of this mixture for contacts he claims a nearly 50 per cent. reduction in cases.

24. As a prophylactic measure anti-cholera inoculation is considered to be the simplest and most certain remedy. It was first introduced by Haffkine into India. The cholera vaccine, which is prepared at Kasauli, consists of sterilized pure cultures of the cholera vibrios. The vaccine is injected into any part of the body where the subcutaneous tissue is loose, the convenient situations being the back and the outer surface of the upper arm, and the front of the chest about 3 inches below the clavicle. At first half a c.c. of an emulsion of 4000 millions is inoculated, and then 7 to 10 days later 1 c.c. containing 8000 millions is inoculated Children under 4 years of age are not usually inoculated. Persons suffering

1. Ind. Med. Gazette, June, 1923, p. 258.

from fever and bowel complaints should not also be inoculated. The immunity thus artificially acquired usually lasts from four to six months or a little more. Hence inoculations should be performed just prior to the cholera season. As a precautionary measure individuals should undergo cholera inoculation when the disease is anticipated, or an epidemic exists, and when they are about to proceed on active service in cholera-infected areas or when they proceed on pilgrimages to dangerous places in seasons when cholera is likely to break out. But in India it is a very difficult and almost impracticable problem to inoculate the pilgrims visiting Hardwar and other places of worship on certain festive occasions when hundreds of thousands congregate together. At the Kumbh fair of Hardwar in April 1927 the Director of Public Health, U. P. could not carry out the suggestion that all pilgrims to the fair should be inoculated against cholera, but had to depend on the sanitary precautionary measures, and they were so elaborate and thorough that very few cases (58) of cholera occurred at the fair and the disease was successfully checked from spreading to the neighbouring districts in the United Provinces as well as in the Punjab.

DYSENTERY.

This is a disease met with in the temperate, tropical and subtropical countries. There are two main forms of the disease, *viz.*, amœbic dysentery and bacillary dysentery.

Amoebic Dysentery.—This is generally endemic, and occurs in a sporadic form throughout the year, though it is more common at the beginning of the rainy season. It does not spread in an epidemic form.

The disease is caused by a protozoon, *Entamœba histolytica*. It infests the large intestine of man, gets into the submucous and muscular coats and produces the typical amœbic ulcer. It may be carried from the intestine into the liver by means of the portal vein, where it produces the so-called

typical abscess of the liver. The parasite is free in the intestinal ulcers, and multiplies by fission or division. Some of them leave the ulcers, and pass into the lumen of the intestine, where they gradually form into cysts. This cyst formation or encystation is the natural sequence in the life history of *Entamœba histolytica*, and occurs only in the intestine of the infected individual. These cysts are clear, refractile, spherical bodies, containing one to four nuclei. They escape in the stools and are the only form which if ingested can bring about an attack of amœbiasis. The cysts survive outside the body for several weeks, if kept cool and moist. They are destroyed immediately by desiccation, and degenerate rapidly at a high temperature.

The disease is spread through drinking water contaminated with cysts, or through vegetables and other articles of food infected with cysts deposited by flies. It should also be noted that "carriers" who pass cysts with their fæces without being infected may continue to be a source of infection to the community for a long time. The cysts, if swallowed in food or drink, are not affected by the gastric juice in the stomach, but pass into the intestine, where the cyst wall is dissolved by the pancreatic juice and the small amœbæ are set free to grow and multiply in their normal habitat.

Bacillary Dysentery.—This occurs in an epidemic form in jails, lunatic asylums, schools and famine and military camps. It is prevalent in the autumn and in the rainy season, when the temperature is high and the atmosphere is saturated with humidity. It is caused mainly by a specific bacillus, called *Bacillus dysenteriæ Shiga* and *Flexner*—'*Y*'. It is passed in the mucous stools of persons suffering from the disease, and gains access to the body by the mouth in drinking contaminated water. In some cases it is carried directly from man to man through soiled linen, utensils, fingers, etc. House-flies also play an important part in spreading the disease by carrying the bacilli and infecting milk and other articles of food.

Badly cooked food or uncooked and irritating food, overcrowding, unhygienic conditions, chill and mental depression are the predisposing causes that spread the disease.

Prophylaxis.—The prophylactic measures are the same in both the forms of the disease. They consist in isolating the patients, who should be treated promptly and properly. They should not be allowed to mix with other persons during the convalescent period till three successive examinations of the fæces give a negative result. "Disease carriers" should be segregated, and treated efficiently. In the case of amœbic dysentery they should be given emetine-bismuth-iodide as a routine treatment, and "bacillary carriers" should be treated with mercuric chloride and *bel* fruit or may be treated with the mixed vaccine and anti-Shiga serum.

Water-supply should be attended to. Wells should be permanganated, and water and milk should not be used, unless they are boiled.

Food should be properly and well cooked, and should be kept covered till it is eaten.

Raw vegetables should not be eaten, but they should be washed with hot water, and then well cooked.

Latrines should be kept perfectly clean and neat, and the stools should be disinfected with phenol, or with any other disinfectant, and then buried or burnt.

Filth should not be allowed to be collected anywhere, especially near latrines, and there should be no cattle sheds in their neighbourhood, so that flies may not collect there. Every precaution should be taken to prevent flies from coming near the latrines.

Sick people should not use the same *lota* for drinking purposes as they would take to latrines for purposes of ablution.

The germs of bacillary dysentery are killed by exposure to sunlight in half an hour, but remain active for some time if left in the folds of linens, blankets and bedsheets. These

soiled articles should, therefore, be unfolded and exposed to sunlight, and should be thoroughly disinfected and washed with boiling water, before they are given to healthy persons for use.

TYPHOID FEVER (ENTERIC FEVER).

This disease is caused by a micro-organism called *Bacillus typhosus or Eberth's bacillus* with which the name of Gaffky has been associated.

This bacillus is rather short, thick, flagellated and motile with rounded ends. It is quite distinct from *Bacillus coli*, though in the beginning it was thought that it was the same as *Bacillus coli*, which underwent certain changes while growing in sewage, so as to be able to produce symptoms of typhoid fever, when introduced into the human system. It readily grows on various nutritive media and resists drying for months in thick layers, but when spread out in thin layers it dies in from five to fifteen days.

The bacillus is found in the blood, faeces and urine of patients suffering from typhoid fever, and occasionally in the sputum, perspiration and rash (macular spots) on the abdomen. After death it is found in Payer's patches, mesenteric glands, spleen, gall bladder and various other organs. Besides this parasite, there are two more distinct varieties, *viz.*, *Bacillus paratyphosus A* and *Bacillus paratyphosus B*, which give rise to modified symptoms. The former is most common in India and other countries of the East, and the latter in Europe.

Aetiology.—Typhoid fever is met with both in temperate and tropical climates. It is more common in towns than in rural areas on account of the former being more filthy and overcrowded. European immigrants to the Tropics within the first three years of their arrival are more prone to the disease than residents of long standing. It was formerly supposed that the natives of India did not suffer from this disease, but Rogers noticed these attacks among Indians as well as Europeans. However, if it is less common among Indians,

it is due not to the fact that Indians as a race are immune, but because they suffered during their childhood and so got artificially immune owing to a previous attack, or they were acclimatised to it by living in constant contact with typhoid and similar toxic agents.

Season.—In the temperate countries it is more prevalent in the autumn, but in India it occurs more during hot and dry months, especially in Bengal and in the Punjab, though in Bombay it is met with during the monsoon months.

Incidence.—It is generally a disease of the young, who are most likely to be attacked between fifteen and twenty-five years of age. It attacks males more than females. The mortality is usually 10 to 15 per cent.

Incubation Period.—The average incubation period varies between twelve to fourteen days, but in some cases it may range from a few days to thirty. It appears to be much shorter, when the poison is introduced by water or by milk.

Modes of Infection.—Infection is conveyed from the sick to the healthy directly from the discharges of the patient, *viz.*, fæces, urine and possibly sputum, or indirectly by means of water, milk, food, shell fish, mussels, oysters, dust, fomites and flies. Convalescents and others, who harbour typhoid bacilli, and who are, therefore, called "bacilli carriers," play a very important part in spreading infection, especially if they happen to be cooks, bakers, sweetmeat-sellers and dairymen.

Lynn-Ge[1] has studied the possibility of the transmission of typhoid fever by bed bugs, and has come to the conclusion that typhoid fever can be transmitted by bed bugs and that typhoid bacilli can be isolated from various parts of the bed bugs.

Prophylaxis.—The following measures should be carried out in order to check its spread :—

1. Correct diagnosis of the disease.
2. Its notification to the health authorities.

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1. National Med. Journal of China, Feb., 1926, p. 62 ; Brit. Med. Jour., Aug. 7, 1926, Epitome, p. 20.

3. Isolation of the patient to an infectious diseases hospital as far as possible.

4. If not possible, the patient should be isolated in a large well-ventilated room, much better if detached from the house, which should contain no unnecessary furniture. It should be kept thoroughly clean, but should not be allowed to be swept or dusted dry. Its door should always be well screened.

5. The stools, urine, sputum and other excretions should be thoroughly disinfected before final disposal.

6. The utensils used by the patient should first be dipped in izal lotion for some time, and then washed with boiling water.

7. The other inmates of the house should not be allowed to eat the remnants of food left by the patient, but they should be first boiled, and then discarded or burned.

8. Thermometers and other appliances used for the patient should be thoroughly disinfected by izal, carbolic or formalin lotion.

9. Bedding, towels, bedsheets, etc., used by the patient should first be disinfected, and then washed with boiling water. If possible, it is better to burn them.

10. The nurse and other attendants must protect themselves by first disinfecting their hands with mercury lotion and then washing them with soap and water, every time they handle the patient or his discharges. They should never eat or even drink water in the patient's room.

11. The room occupied by the patient must be thoroughly disinfected with 1 in 1,000 mercury lotion after the patient has become convalescent or has died. It should then be white-washed.

12. The floor, seat and walls of the latrines and the privy pans should be thoroughly disinfected.

13. On the occurrence of a typhoid case, wells in the neighbourhood should be thoroughly disinfected, and the

people should be instructed to drink boiled water as well as boiled milk.

14. They should not drink water or take other eatables sold on the station platforms during their railway journey.

15. They should protect their milk and food against the visit of flies.

16. Frequent bacteriological examinations of discharges (fæces and urine) of enteric convalescents should be insisted on, and they should be warned of being a source of danger to their relatives and to the community, if they are found to be "bacilli carriers." Their excrements should be disinfected. Such persons should, on no account, be employed in the sale of food stuffs or have anything to do with the preparation or handling of food, milk or drink supplies. If they happen to be students, they should not be allowed to live in the school boarding-house or hostel.

17. Sir Almroth Wright has introduced anti-typhoid inoculation in which the dead cultures of bacteria are used. It has been ascertained that two inoculations done at an interval of ten days confer more or less immunity. This is mostly practised when a large number of people are to be exposed to a common danger as in war time. Before the introduction of this inoculation, more men in the army used to die from typhoid fever than from powder and shot, but now the incidence of the disease is very low. During the last Great War it was found that the typhoid vaccine did not prove protective against paratyphoid infections. Hence a polyvalent vaccine consisting of a mixture of *B. typhosus* and *B. paratyphosus-A* and-*B* was used as a prophylactic against the infection of these diseases. The official vaccine used for the army contains 1,000 million typhoid bacilli, 750 million paratyphoid-A and 750 million paratyphoid-B in each cubic centimeter of the liquid medium in which the dead bacilli are suspended. The dose for adults is 0.5 c.c. at the first inoculation and 1 c.c. at the second time after an interval

of ten days. The local and general effects of the reaction are comparatively slight in the majority of instances, and the immunity conferred lasts from six months to a year.

TUBERCULOSIS.

This is a disease caused by the Tubercle bacillus discovered by Professor Koch in 1882, and occurs in the human system in different clinical manifestations, as acute general tuberculosis, phthisis (pulmonary tuberculosis), tuberculous meningitis, tabes mesenterica, tuberculous glands, etc.

All warm-blooded animals appear to be susceptible to this disease, though some are known to suffer more than the others. Thus bovines suffer most. Goats are said to be immune. Apes and monkeys do not suffer from it in the wild state, but suffer most when in confinement.

Chickens and fowls are frequently infected by what is known as avian tuberculosis. Pigeons, ducks and guinea-fowls are also sometimes found infected. Reptiles and fish have been described as suffering from tuberculosis, but the bacilli found in the cold-blooded animals are not infective to man, as they cannot grow at the body temperature of mammals.

The disease is prevalent both in temperate and tropical countries, and is more prevalent in large over-crowded cities and towns than in open and scattered villages. Of late it has been on a great increase in India. It is very rare in the sandy deserts of Rajputana, but lately cases have been noticed there also, possibly owing to the people of that province migrating to the big cities such as Calcutta and Bombay, being infected there and then carrying infection to their own villages and towns on account of facilities in railway travelling.

Predisposing Causes.—These are badly ventilated, dark and dirty houses, which are rarely visited by the sun during the day, general poverty of the people, scantiness of food, alcoholism and consequent lowered vitality, early marriages, frequent child-bearing and *purdah* system, especially in

Northern India. People working in ill-ventilated and badly lighted factories which are laden with dust or where the air is charged with moisture, are liable to tuberculous infection, especially of the pulmonary kind. Certain grinding trades, such as file making and stone cutting which tend to inhalation of dusty particles predispose the workers to the infection of this disease.

The disease is not hereditary in the sense that a child gets infection from its parent during its intra-uterine life. The child, when born, is free from tuberculosis but it may contract the disease from its mother who is a victim to it.

Tubercle Bacilli.—These occur usually as short, fine rods, often slightly bent or curved and, on an average, are half as long as the red blood corpuscles. The bacilli grow very slowly outside the body, requiring special nutritive media for the purpose of culture. They are capable of retaining their virulent action for several months in dried sputum or dust kept in darkness. They are not destroyed by the action of the gastric juice in the stomach, nor are they affected by the putrefying processes going on in dead tissues for many weeks. They are, however, killed quickly by direct exposure to sunlight, or by certain antiseptics, such as a solution of carbolic acid of strength 1 : 20.

The germs are contained in the sputum of phthisical patients and in discharges from all other open tuberculous lesions, wherever they may be situated in the body. Sometimes they are swallowed along with sputum by phthisical people, and are then discharged with the fæces ; but sputum is the chief source of danger in very many cases.

Modes of Infection.—Infection may take place by inhaling fine dust containing tubercle bacilli derived from the dried sputum of an infected person or by inhaling fresh sputum droplets containing bacilli, which are sprayed out by sick persons during the act of coughing, sneezing or any other violent expiratory action. This is much more liable if the

room is stuffy, ill-ventilated and dark, and hence the danger of sleeping in the same room with a phthisical patient.

Infection may also occur by handling injudiciously sputum and other discharges, and then contaminating food or water by means of fingers.

Flies are also known to spread infection first by sitting on the infected sputum or other discharges and then on food, water, milk or fingers, or even on lips. Ingestion of diseased meat is known to have produced the disease.

Lastly, the disease is contracted by direct contact as by kissing or indirectly through infected tobacco pipes or hookahs, spoons, glasses, cups, pencils and toys.

Human and Bovine Tuberculosis.—At the International Medical Congress held in London in 1901, the medical profession was very much surprised to hear from Dr. Koch, the eminent German bacteriologist, that human and bovine tuberculosis were different and that man would not contract bovine tuberculosis from cattle. As most of the other famous medical men did not agree with his views, this question was referred to a Royal Commission by the British Government in 1907. The conclusions that they arrived at after great deliberation are as follows :—

There can be no doubt but that in a certain number of cases tuberculosis occurring in a human subject, especially in children, is the direct result of introduction into the human body of the bacillus of bovine tuberculosis and there can also be no doubt that in the majority at least of these cases, the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacillus is clearly a cause of tuberculosis and a fatal tuberculosis in man.

It is, therefore, a settled fact that man is infected by bovine tuberculosis, but some physicians believe that in India this kind of infection is very rare on account of the custom of the people of using boiled milk, but at the same time, they conveniently seem to forget that milk is liable to be

contaminated by flies coming from cowsheds after it is boiled, as vessels containing it are, as a rule, kept open. Besides, the cows and buffaloes are, in the majority of cases, stabled in the very houses which have been occupied by the owners, and children are also found playing about on the floor in the cowsheds scattered over with cowdung and urine, which may have been infected.

Preventive Measures.—The following measures should be adopted to check the spread of tuberculosis, which is rightly considered a white plague as it takes away so many young lives and bread-winners of families every year, and thus causes a great economical loss to the nation.

1. There should be need of early diagnosis of tuberculous cases, so that they may at once be notified to the sanitary authorities.

2. Tuberculosis being a contagious disease, it is better to isolate cases who pass bacilli in their sputum, and who are thus a direct source of danger to the community. For this purpose sanatoriums should be established in different districts and provinces. But sanatoriums are very costly and considered to be white elephants by some medical men, as sick individuals, when they are discharged from these institutions, do not find the same sanitary arrangements and facilities for treatment in their houses, and consequently fall ill again on reaching their homes. Hence both money and time are wasted on them. It is, therefore, much better to have some cottages kept separate in villages and towns, where consumptives may be isolated and allowed to work in fields or gardens attached to them under the supervision of medical men in charge of travelling dispensaries. There is another advantage that the patients will be nearer their own relatives—a fact not to be disregarded in India.

3. Towns and cities should be remodelled, wherever possible. Congested areas should be opened up, and open squares with parks should be laid out, and streets should be

widened out. Houses should be well ventilated on all sides, so that the sun should penetrate each and every room.

4. The resisting power of the poor labouring class should be increased by housing them in cheap and well-ventilated houses and by increasing their wages, so that they may get enough to eat. They must be persuaded to give up alcohol and other intoxicating drugs which help to lower their vitality.

5. There should be systematic inspection of school children, so that those children who are found to be suffering from tuberculosis may be separated, and an arrangement should be made to school them in the open, under shady trees, if possible. The school buildings should also be roomy, spacious and well-ventilated.

6. Popular lectures by competent medical men on tuberculosis in all its aspects regarding the mode of infection and prevention should be frequently arranged in streets and *mohallas*, in towns and in prominent places of villages ; and for this purpose anti-tuberculosis leagues should be organised in big cities. Printed leaflets written in easy local vernaculars should be distributed among patients attending dispensaries and hospitals.

7. There should be special tuberculosis dispensaries in every town and city, where out-door patients should be treated with tuberculin.

8. Cows and buffaloes should be examined for tuberculosis, and in case of doubt, tuberculin test should be tried. There should be an efficient control of milk supplies as well.

9. In all big municipalities an arrangement for free bacteriological examination of sputum and milk should be made.

10. Veterinary surgeons should be appointed to inspect meat and animals to be slaughtered for human consumption.

11. Consumptives should be advised to hold a handkerchief to their mouth while coughing and to spit only in a spittoon or an earthen *handi* provided with a cover, that

contains some phenyle or other smelling disinfectant likely to drive away flies. Mercuric chloride should not be used to disinfect sputum, as it does not penetrate the albuminous mass. The sputum should then be burnt or buried far away from a water-supply as in the case of cholera evacuations.

12. These patients should be forbidden from promiscuously spitting in public halls, schools, theatres, public conveyances, tram cars and railway carriages. For their information notices "Spitting not allowed" should be put up in prominent places. If they have to expectorate outside their houses, they should do so into a small wide-mouthed bottle with a well-fitting cork or into a pocket spittoon, which they should carry in their pocket. If they have neither of these, they should spit into linen handkerchiefs, which should then be disinfected and washed, or into paper handkerchiefs which could be easily burnt afterwards.

13. Rooms occupied by phthisical patients should be well lighted and ventilated. Their floors should never be swept with a broom, lest dust-laden germs be disturbed, but should be wiped with a piece of rag soaked in phenyle or carbolic lotion. All the utensils, such as plates, cups, spoons, etc., should be kept separate for their special use, and should be carefully boiled with water. All the wearing apparel and linen used by them should not be mixed up with the clothes of the other inmates of the house, but should be kept separate and boiled before they are sent to a washerman.

14. Relatives and attendants should never receive sputum in their hands from the mouths of sick people.

15. Persons nursing them should observe perfect cleanliness in washing their hands, etc.

TRYPANOSOMIASIS (SLEEPING SICKNESS).

This disease is endemic in West and Central Africa. Race, sex and age have no influence on the susceptibility to this disease, but fishermen and boatmen are more liable to be affected, as their occupation compels them to live along

the banks of lakes and rivers, which are the usual haunts of tse-tse flies.

Aetiology.—The disease is caused by a protozoon parasite, *Trypanosome gambiense.* It is an active, wriggling, polymorphic organism, varying in length from 18 to 33 microns and in breadth from 1 to 3 microns. It consists of a spindle-shaped mass of cytoplasm composed of an inner granular endoplasm and an outer ectoplasm. In the endoplasm there are two nuclei. The larger, which is known as the tropho-nucleus, is oval in shape, situated about the middle of the body and in front of the chromatic granules in the cytoplasm. The smaller, called the kinetonucleus, is oval and is generally located near the posterior non-flagellate end of the parasite. A small basal corpuscle or end-bead is situated close to the kinetonucleus, from which arises a long flagellum, which is connected with the body by an undulating membrane. The parasite moves through the blood or other fluids of the body by the aid of the wave-like motions of this membrane and the lashing movements of this flagellum. It is found in the peripheral blood, in the juice of the enlarged lymphatic glands and in the cerebrospinal fluid. It is also found in the substance of solid organs, especially the brain. Like the malarial parasites it requires for its complete development two hosts, one of which is a vertebrate and the other a blood-sucking invertebrate. These parasites may be found in the blood of the big game which abound in Africa.

Mode of Transmission.—The disease is transmitted from the sick to the healthy by the bite of a tse-tse fly, Glossina palpalis, which acts as an intermediate host for the trypanosomes. When the fly bites an infected man or animal, it sucks the blood containing the trypanosomes, which on entering the stomach pass into the midgut. Here they multiply by division, producing long-snouted motile forms, which between the twelfth and twentieth day pass along the hypopharynx into the salivary glands. They attach themselves to the walls of these glands by means of their flagella, and

assume a crithidial shape. These again divide, and form minute trypanosomes, which are similar to those found in the blood of the vertebrate, and are once more infective to man. The salivary gland development requires two to five days, and this happens in about eight per cent. of flies experimentally infected. The whole cycle of development of the parasite in the fly usually occupies from 20 to 30 days, after which the fly becomes infective, and probably remains so for the rest of its life. A temperature of 75° F. to 85° F. is favourable for the development of the parasite in the body of the tse-tse fly. It is possible that the tse-tse fly may transmit the disease in a mechanical manner by carrying the parasites along its proboscis, and then inoculating them into the blood of another individual, but this occurs only for a very short time after an infective feed, as the blood adhering to the biting parts soon dries up, and no sooner does this occur than the parasites perish.

Another form of sleeping sickness which is mostly common in Rhodesia and East Africa is caused by *Trypanosoma rhodesiense*. This parasite morphologically resembles mostly *T. gambiense*, but the trophonucleus in some cases is located at the posterior extremity. It is conveyed by the bite of the tse-tse fly, *Glossina morsitans*. The development of the parasite in the body of this fly is almost similar to that in Glossina palpalis.

Prevention.—This chiefly consists in the isolation of the sick, protection of the sick and the well against the bites of the tse-tse flies and destruction of the flies.

Those who are found to be suffering from sleeping sickness should be removed to a locality where there are no tse-tse flies, or should be isolated to a properly screened hospital. Here they should be properly treated with atoxyl," Bayer 205 " or arsphenamine.

Those who are well should not encamp within the fly zone, and should travel during the night in such localities, as

the tse-tse flies generally bite during the day time. They should also protect themselves against their bites by wearing suitable white clothing, such as veils, gloves, *putties* and high boots though they may be uncomfortable at times.

It is very difficult to exterminate the tse-tse flies, but it is possible to reduce their number by clearing all brushwood and jungle along the banks of lakes and streams for 100 yards and for 300 yards round about villages.

CHAPTER XX.

RELAPSING FEVER, TYPHUS FEVER, KALA-AZAR AND PHLEBOTOMUS FEVER.

RELAPSING FEVER.

THIS is also called famine fever, tick fever, and seven days' fever. It is a highly infectious disease, having a close relation to typhus fever. It is found in Europe, Amercia, Africa and Asia. In Asia it is known to occur in China, Sumatra and India. In India it is largely met with in the Presidency of Bombay and is endemic in the north-west parts of the Punjab. It is present in the Kumaon Hills and the western districts of the United Provinces, while it is not known to have occurred in Bengal, Assam and Madras.

Aetiology.—The causative organism is a delicate spiral filament, known as *Spirochæta* (*Spironema*) *obermeieri* or *recurrentis*. In India the organism causing this disease was first discovered by Vandyke Carter, and is, therefore, called *S. carteri*. The spirochæta is also the cause of the African type of the disease, though with slight morphological differences, and is called *S. duttoni*. This parasite occurs in the blood plasma during the pyrexial stage of the disease only. It is not present in the peripheral blood in the apyrexial interval, but collects in the spleen and bone marrow where it may be undergoing reproduction. These organisms have also been found in the sweat and tears, and have been proved capable of passing through the unbroken skin and the intact mucous membrane.

The predisposing causes of the disease are filth, scarcity, poverty and overcrowding. It is, therefore, very common among the poorer classes of the population.

Incubation Period.—The incubation period is very short. It varies from five to seven days.

Protection.—Unlike other specific fevers one attack does not confer immunity against subsequent attacks.

Mode of Transmission.—It has now been definitely proved that the disease in India and Europe is conveyed from the sick to the healthy by the agency of lice (*Pediculus humanus*). Nicolle and his associates have shown from laboratory experiments that the spirochætes quickly disappear from the stomach of the louse after they have been fed with blood from an infected person, and reappear in the cœlomic fluid after about eight days. The lice are generally infective from the third to the fifteenth day, and usually on the sixth day they are most infective. They remain infective for twenty-eight days. Infection takes place not by the louse bite, but by the parasites escaping from the crushed louse and making their way into the blood through the puncture caused by the bite or through the excoriated skin caused by scratching with the finger nails provoked by the irritation of the bite. The infective agent may also be conveyed on the fingers to the nose or eyes, and infect the system by absorption through the mucous membrane. It has also been proved that in the case of an infected pregnant woman the parasite can pass to the fœtus through the placenta.

Lice.—These are small, flat but elongate, wingless insects having a small head and stout thick legs ending in strong claws, which are used as pincers to cling firmly to the host. The mouth parts have in front a short beak or proboscis extending into a thin slender stylet, which is used to suck the blood by piercing the skin of the host. The thorax is indistinctly segmented and is always broader than the head. The abdomen is divided into segments varying from six to nine in number. The last segment is indented in the female, but is rounded in the male with a spine-like penis. The spiracles are prominently situated on the sides of the abdomen. The lice which infest men are *Pediculus capitis* (head louse), *Pediculus corporis* or *vestimenti* (body louse) and *Phthirius pubis* (crab louse). The head louse and the body louse are the

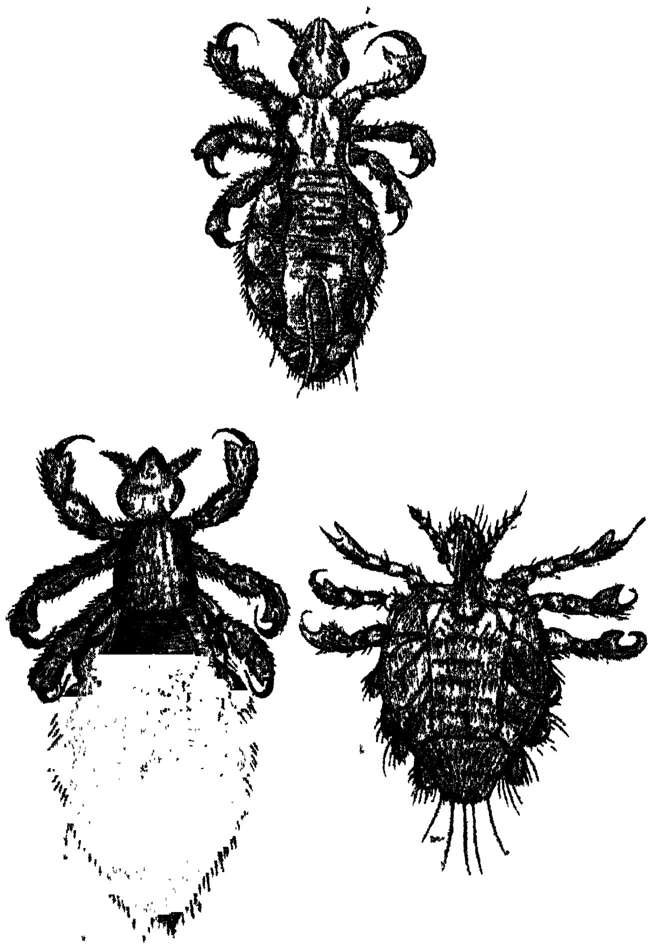

Fig. 65—1. Pediculus capitus, 2. Pediculus corporis; 3. Phthirius pubis.

varieties of the same species, known as *Pediculus humanus*, and are concerned in transmitting relapsing fever, typhus fever and trench fever. They also play a part in the development of the inflammatory conditions of the skin by the scratch provoked by the irritation caused by their bites. The head louse usually prefers the hair of the head as a habitat, and often varies in colour according to the colour of the skin of the human race on which it lives. The body louse is a little larger than the head louse, and infests the seams and folds of the clothes. The female is somewhat larger than the male and varies from one-eighth to one-sixth of an inch in length. It is dirty-white in colour and has an oval, elongated head with large antennæ. The crab louse is usually found infesting the pubic hairs, but may also be found on the eyelashes, eyebrows and the hairs of the axillæ. It is greyish-white in colour, and is about one-sixteenth of an inch in length, the male being about half the size of the female.

The life-histories of these lice are similar, inasmuch as after emerging from the egg they pass through three moults before attaining sexual maturity. The eggs which are commonly called nits are oval, whitish in colour and are about one-twenty-fifth of an inch in length with a little lid at the larger end through which the hatching takes place. The eggs of the head louse and of the crab louse are firmly cemented to the hair, while those of the body louse are cemented to the fibres of the clothing, especially along the seams and folds, though they are sometimes found attached to the body hair. The eggs hatch in from eight days at 32° C. to five weeks at a lower temperature. The first moult occurs after two days; the second, two days later; and the third, after three days. The life-cycle is complete in about sixteen days.

The African type of relapsing fever or tick fever is conveyed by the agency of a tick (*Ornithodoros moubata*) or its larva. Leishman has shown that the spirochætes remain motile for several days in the stomach of the tick after ingestion. But when they pass into the intestinal tract, they lose

their motility and break up into chromatin granules which pass into the cells of the Malpighian tubules and into the tissue of the ovary. From the ovary they pass into the eggs, and through them may pass into a second or even a third generation of ticks. Infection is transmitted through the excremental matter deposited by the side of the puncture the tick makes by its bite; from here the parasites enter the blood, aided by the scratching provoked by the irritation following the tick bite. The tick may remain infective for more than a year after it has fed on an infected person.

Ticks.—These are not true insects, but belong to the order Acarina, which also includes the Acarus scabei- the cause of scabies (itch). Ticks belonging to the family Ixodidæ are parasitic to men, animals, birds and reptiles. They are flat and oval or triangular in shape, usually tapering to the anterior end, but after a full meal of blood they become so much engorged as to resemble beans or nuts of some kind. The females are usually larger than the males, and are almost half an inch in length, when they are fully grown and engorged.

Ticks have an unsegmented body covered with a leathery cuticle, and four pairs of legs in the adult stage and three pairs of legs in the larval stage. The capitulum or head which is attached in front is somewhat triangular in shape and carries the mouth parts. The latter consist of the hypostome, a pair of mandibles (cheliceræ) and a pair of palpi. The hypostome is an elongated structure composed of two symmetrical halves, beset with row after row of minute teeth, called denticles, on its ventral surface. The mandibles are situated on either side of the median line, and are provided with hooks. They lie dorsal to the hypostome. The palpi are composed of four segments, and owing to the presence of long hairs on their internal aspect are probably sensory in function. The spiracles or stigmata lie behind the fourth pair of legs on either side of the body. The genital pore is situated

on the ventral surface behind the capitulum. The anus is situated in the median line behind the posterior pair of legs.

The life cycle of the ticks is in the usual four stages: egg, larva, pupa (nymph) and adult. The eggs are deposited in the ground in large numbers. In a period varying from two or three weeks to several months according to the temperature the eggs are hatched into larvæ which are minute creatures, popularly known as "seed ticks". They have only six legs, but no spiracles or sexual orifice. The larvæ attach themselves to a vertebrate host, on the blood of which they feed. When engorged with blood they drop to the ground, and moult, emerging as nymphæ having eight legs and a pair of spiracle ssituated one on each side of the body. The nymphæ

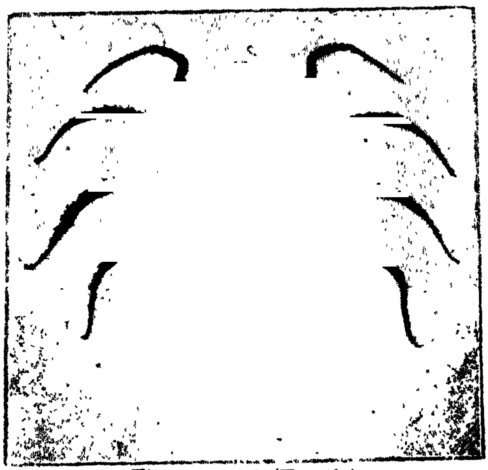

Fig. 66—Tick (Female).
Ornithodoros moubata.

soon crawl up grasses or weeds and wait until they can attach themselves to a suitable host. Having gorged blood they drop to the ground, moult and become sexually mature adult ticks. They again seek a fresh host, on the person of which they mate together. After fertilization the male drops off and dies immediately, but the female feeds on the blood of its host for the development of her ova.

The tick which is the carrier of relapsing fever in Africa is known as *Ornithodoros moubata.* It is oval in shape and greenish-brown in colour. The female is about 8 mm. long and 6 to 7 mm. broad. It lives in cracks in the mud floors of thatched huts of the people, and comes out at night to feed on the inmates of the huts. It feeds slowly and may remain attached to its host for two to three hours. It attacks both man and beast. It is frequently carried long distances in mats, beddings, and tent equipage. After a meal of blood the female deposits eggs in batches of one hundred to three hundred at short intervals. Inside these eggs the larvæ develop and moult, undergoing their metamorphosis into eight legged nymphæ, which hatch after a period of about twenty days. After three or four days these nymphæ suck the blood of their hosts. The adult ticks moult after each meal of blood, and may live about a year. In habits the tick resembles the common bed-bug.

There are other varieties of ticks which transmit spotted rocky-mountain fever in man and texas fever in cattle.

Prevention.—1. Early diagnosis of the disease and isolation of the patient suffering from relapsing fever. 2. Thorough disinfection of the room occupied by the patient, including destruction of vermin, *viz.*, lice. Lice and nits can be destroyed with kerosene, turpentine, dichlorethylene or tetrachlorethane. They are killed more easily by exposure to dry heat than to moist heat. They should never be killed by crushing between the nails. 3. Huts or houses of little value should be burnt, if possible. 4. Clothes infected with lice should be immersed for half an hour in a soap solution containing 2 per cent. of trichlorethylene or 10 per cent. tetrachlorethane. However, it is better that they should be boiled, baked or steamed. 5. Articles, likely to be injured by heat, may be subjected to sulphur fumes or dipped in carbolic acid solution. 6. Great attention should be paid to personal cleanliness, and underwear should be kept clean and neat. 7. Bites by ticks should be avoided, and for this purpose people should

keep aloof from vermin-infected places, especially where the disease prevails. They should use mosquito nets at night. Other preventive measures of the first importance are those which combat poverty and overcrowding.

TYPHUS FEVER (TYPHUS EXANTHEMATICUS).

This is also called spotted fever or jail fever. It is prevalent in Ireland, Russia and certain parts of Southern Europe, as well as in Mexico. It occurs in certain subtropical countries, as in North Africa, but is rare in tropical regions. It is met with in India, especially in the Kumaon Hills. In 1923 E. S. Phipson[1] reported an outbreak of 16 cases of typhus fever in a Mahomedan family at Simla. It is entirely a disease of filth, overcrowding and poverty. Hence it is usually prevalent during the winter months, when the poor people huddle closely together in ill-ventilated rooms owing to want of proper clothing. The epidemic outbreaks very often follow wars and famines. During the last Great War typhus fever occurred in an epidemic form in several countries, *e g.*, Serbia Bulgaria, Turkey, Russia, Poland, Germany and Austria.

Aetiology.—The causative organism of the disease has not yet been definitely known. But as a result of careful researches Wolbach, Todd and Palfrey have come to the conclusion that the causative agent of typhus fever is a minute organism, *Rickettsia prowazeki.* It was named by Rocha Lima, in 1916, in memory of Ricketts and Prowazek, who died of typhus fever during the course of investigations of the disease. It is bacilliform, less than half a micron in length and occurs in pairs and clusters within the leucocytes of the peripheral blood of a typhus patient from the seventh to the twelfth day of the disease. It has also been found in the vascular lesions and in the endothelial cells of the liver. Similar organisms, commonly called Rickettsia bodies, are stated to be the cause of Trench fever and Rocky mountain spotted fever.

1. Ind. Jour. Med. Research, 1923, XI, p. 305.

Another organism associated with typhus fever is Bacillus X, 19 of the Proteus group, which was cultivated from the urine of a typhus patient by Weil and Felix during the last Great War in 1915. It is agglutinated in high dilutions even up to 1 in 30,000 by the serum of patients suffering from typhus. This agglutinating reaction is known as Weil-Felix reaction, and affords a valuable means of recognising the disease. In about 50 per cent. of the cases the reaction is found on the fifth day of the disease and in practically all, by the tenth day. The bacillus, however, is not capable of producing the disease, nor does it confer immunity to it.

Incidence.—The adults of both sexes are attacked by the disease, but the mortality is much higher among the males between the ages of ten and fifteen years. The rate of mortality is, on an average, about 20 per cent. and is higher in adults than in children.

Incubation Period.—This is usually 12 days, but may vary from 5 to 20 days.

Mode of Infection.—The disease is transmitted from the sick to the healthy by means of lice (Pediculus humanus). The organism is found in the epithelial cells of the alimentary canal of the infected louse, as single granules, diploid bodies or in clumps, evidently resulting from multiplication of the individual organism. The louse is infective from the fourth to the seventh day after it has sucked the blood of a typhus patient. The disease is introduced through the fæces of the louse, the organism gaining entrance through the puncture made by the bite of the louse or through an abrasion made by scratching.

Megaw[1] believes that typhus fever occurring in certain districts of India is the same as, or at any rate, closely allied to, Rocky Mountain fever, affects the animals of the jungle and is transmitted to man by the bite of a tick. But Cragg[2]

1. Ind. Med. Gazette, Oct., 1921, pp. 361, 371.
2. *Ibid.*, Aug., 1922, p. 291.

suggests that the fever occurring in an endemic form at Bhim Tal and Sat Tal, in the lower Kumaon Hills is typhus fever, and is carried by lice. On the contrary W. Fletcher[1] reports that sporadic cases of typhus fever occur throughout the Malay States, and that these may possibly be carried by a tick.

Preventive Measures.—The patient suffering from typhus fever should at once be isolated to a hospital or a separate room. The hair of his scalp should be cut short, or shaved, and the hair of his face, axilla and pubes should also be shaved. Such hair should be collected and burnt. The patient should then be thoroughly washed with a soap solution containing 2 per cent. trichlorethylene or 10 per cent. of tetrachlorethane. It is also advisable to rub him all over with 10 per cent. camphor oil, or to spray him or to rub him down with kerosene, benzene or gasolene to destroy lice or their nits. The clothes of the patient should be immersed in boiling water, or should be steamed or baked. The room occupied by the patient should be thoroughly fumigated with sulphur dioxide or formaldehyde. Isolation of the patient should continue for five weeks.

Doctors and nurses, who have to attend on the sick, should protect themselves from the bites of the infected lice by wearing overalls fastened round the neck and wrist by adhesive plasters. They should also wear rubber gauntlet gloves, boots and leggings. The head should be covered by a closely fitting cap.

The contacts should be quarantined for 16 days.

KALA-AZAR.

Synonymous with Tropical splenomegaly, Dum-Dum fever, Burdwan fever and Kala-dukh, or-Jwara.

This is a specific and chronic disease, characterized by an irregular fever, enlargement of the spleen and liver, marked anæmia and general emaciation. It is a disease of tropical

1. Jour. Royal Army Med. Cor., Oct., 1925, p. 274.

and subtropical countries. It is found in India, China, Sudan and Western Abyssinia. It also occurs in parts of Spain, on the Italian Coast, in Malta, Greece, Asia Minor and Turkestan. In India it largely prevails in the moist plains of Bengal, Behar and Assam. The other endemic foci are Madras and the south-east parts. It has been observed in the eastern districts of Oudh. Mudaliar and his associates have noticed cases in the Western Coast.[1] In the report of the Kala-azar Commission in India (1926) it is said that the disease generally does not occur at or above an altitude of 4,000 feet, and Shillong which is situated in the endemic area but at a height of 5,000 feet, is believed to be free from it. However, Major P. Savage, I.M.S., reports the occurrence of two primary cases of Kala-azar at Sanawar in the Simla Hills at a height of 5,700 feet.[2]

Aetiology.—The causal agent of the disease is a protozoal parasite, known as the Leishman-Donovan body or *Leishmania donovani*, named after Leishman and Donovan who first discovered the parasite. It is found in large numbers in the endothelial cells in the capillaries of the enlarged spleen, liver, bone marrow, and lymphatic glands, as also in the skin and intestinal ulcers. It is occasionally met with in mononuclear and polymorphonuclear leucocytes of the peripheral blood.

The parasite is a small rounded or oval body, measuring 2 to 4 microns in length and 1 to 2 microns in breadth and having a granular cytoplasm containing two chromatin masses. The larger of these masses is spherical, stains slightly and is called the macronucleus or trophonucleus, while the smaller is shaped like a little rod, stains deeply and is known as the micronucleus, kinetonucleus or rhizoplast. The parasite multiplies in man by fission or division. It can be cultivated outside the body if grown on hæmoglobin agar medium or N.N.M.

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1. Ind. Jour. of Med. Research, Jan., 1926, p. 581.
2. Ind. Med. Gaz., July, 1927, p. 382.

medium at a temperature of 22° C., when it multiplies and develops into elongated motile flagellated forms. The parasite passes through one phase of its life in the human body, while the other phase of the flagellated stage is passed in an invertebrate intermediary host to complete its development.

Incidence.—Kala-azar attacks both sexes and all ages, but unlike malaria, it shows a predilection for the acclimatised; the old residents; in them it is said to be as severe and fatal as in the case of newcomers.

Period of Incubation.—The period of incubation is not definitely known. It may vary from ten days to three weeks or more.

Mode of Conveyance.—Several blood-sucking insects have been suspected of conveying kala-azar from the sick to the healthy. Patton observed the flagellate stage of Leishmania donovani developing in the intestines of the common bed-bug (*Cimex rotundatus*), and suggested it to be the transmitter of the disease, although the parasite survives only for a short time in the bed-bug. But Mackie, Cornwall and others have proved that the bug cannot transmit kala-azar by biting and that the viable forms of the parasite are not passed in the fæces of the bug.[1] Major Shortt and C. S. Swaminath have also proved by experiments that the bed bug cannot transmit kala-azar directly or indirectly by its bite to the monkey, *Macacus rhesus*.[2]

The dog is the only domestic animal which is known to suffer from kala-azar especially in the Mediterranean countries; hence it has been suggested that the dog flea (*Ctenocephalus canis*) may be the carrier of the disease, but investigations carried out in India have given entirely negative results. Experiments with blood-sucking reduvids of the genus triatoma (conorhinus), lice, cockroaches and house-flies as possible

1. Sci. Mem. Govt., India, Nos. 27, 37, 1907-08.
2. Ind. Jour. of Med. Research, July, 1925, p. 143.

carriers of the disease have also been carried out with negative results.

It has been suggested that in Sudan the infection takes place through the medium of water contaminated with the fæces of kala-azar patients. In the course of the disease there are frequently intestinal ulcerations, and it is possible that the fæces of such cases may contain the leishmania bodies in some encysted form. Turkhud, Krishnan and S. Iyer[1] believe that this is probably the manner of the spreading of the disease in the endemic areas of Southern India, as the incidence of kala-azar in those places is in direct proportion to the insanitary conditions and the improper provisions for the disposal of excreta. They have observed dysenteric symptoms throughout the course of the disease and in advanced cases when the patient is very weak and bed-ridden, and hardly able to move about. But this has also not been confirmed by further researches.

From the experiments carried out by the staff of the Calcutta School of Tropical Medicine and the Indian Kala-azar Commission it has been determined that the sand-fly, *Phlebotomus argentipes*, is the probable carrier of the infection of kala-azar. S. R. Christophers, P. J. Barraud have been able to confirm the findings of R. Knowles, L. E. Napier and R. A. O. Smith that *Phlebotomus argentipes* fed upon the peripheral blood of a kala-azar patient with positive spleen punctures shows typical flagellated forms of the kala-azar parasite developing in the gastro-intestinal canal from the third to the fifth day after the feed. They have further proved that a large number of actively swimming forms of the parasite progress forwards in an anterior direction, and are seen at the anterior extremity of the buccal cavity, close to the commencement of the biting mouth parts, by the seventh or eighth day after two or more feeds. It is, therefore, presumed that the sand-fly becomes infective on the seventh or eighth day after

1. Ind. Jour. of Med. Research, January, 1926, p. 703.

feeding on the blood of a kala-azar patient, and conveys the infection by means of its bite.[1]

Sand-Flies.—These are known as owl-midges, and belong to the genus Phlebotomus of the family Psychodidæ. They are minute, slenderly built insects, measuring from 1.5 to 3 mm. in length and having a greyish or yellowish brown colour. The body, wings and legs are covered with long coarse hairs, often admixed with scales. The wings are narrow. and are remarkable in having many longitudinal veins without any obvious cross-veins. The wings show all the three branches of the second longitudinal vein very distinctly, and in repose are always held erect and divergent over the body. The legs are long and slender, and the abdomen is divided into ten segments. In the female the last segments of the abdomen are flattened, and are provided with a superior and inferior pair of small claspers. In the male they are composed of superior and inferior claspers, submedian lamellæ, internal appendages and the penis. The mouth parts are adapted for piercing and sucking. The antennæ are long and slender, consisting normally of sixteen segments. The proboscis is as long as the head, and contains a number of piercing organs.

These insects are found in tropical and subtropical regions. During the day they generally remain hidden away in cool, moist, shady places in houses, such as bathrooms and latrines. They shun sunlight but seem to be attracted by artificial light, if not too bright. They are seen in large numbers on warm, still nights, but are rarely seen on the nights when cold breezes are blowing. Only the females suck the blood of vertebrates, but in some species the male has this habit also, and possesses a proboscis which is equally well fitted for piercing the skin and sucking blood. Their bites are very annoying and cause great local irritation. They prey upon men and domestic animals, such as fowls, ducks, goats and cows. They may also attack lizards, frogs and snakes,

1. Indian Medical Research Memoirs, No. IV, Feb., 1926, p. 219.

when they are very hungry. On the slight disturbance they move away rapidly by short hopping flights.

After fertilization the female takes a meal of blood. She then retires to some dark, damp place, such as a crevice in a stone or brick wall of a cellar, bathroom, latrine, cess pool, drain or stable, where she deposits her eggs varying from thirty to eighty in number according to the species. The eggs are covered with a thin coating of viscid material which causes them to adhere to substances with which they come in contact. They are elongate in form, varying from 0.15 to 0.5 mm. in length and having a dark brown colour marked with longitudinal surface lines, which are joined at places by fine cross-lines. Under favourable conditions of warmth and moisture eggs hatch into larvæ in six to nine days after deposition, but they are very susceptible to external conditions, and are quickly destroyed by exposure to sunlight. The larvæ resemble caterpillars, and are from 2 to 5 mm. in length. They are composed of an eyeless head with well-developed mouth parts and a cylindrical body of twelve segments but without legs. Each segment of the body is covered with a number of toothed spines arranged in a transverse row, and the last segment is provided with elongate bristles which may be as long as the body. They feed on decaying vegetable matter, and after undergoing four distinct moults develop into the pupal stage. The larval stage varies in duration from two to fourteen days, depending mainly on the temperature. The pupa is also 2 to 5 mm. in length, and is usually enveloped at its anal extremity by the last brownish larval skin with its caudal bristles. The adult insect emerges after from eight or nine to twenty-eight days. The period generally required for the whole development from egg to imago varies from one month in the hot weather to two months in the cold season.

The species of sand-flies which are chiefly found in India are *Phlebotomus argentipes*, *Phlebotomus papatassii*, *Phlebotomus minutus*, *Phlebotomus major*, *Phlebotomus sergenti*,

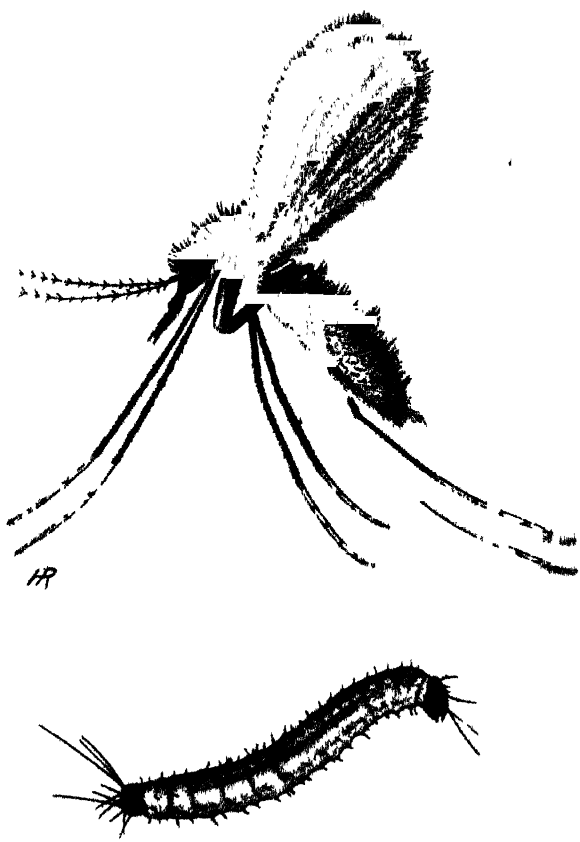

Fig 67—Phlebotomus Argentipes.
(*From Messrs Thacker Spink & Co.*).

Phlebotomus squamipleuris, and *Phlebotomus malabaricus*. Of these *P. argentipes* is concerned in the transmission of kala-azar, and *P. papatassii* is incriminated in transmitting sand-fly fever. Townsend of the U. S. Department of Agriculture has shown that *Phlebotomus verrucarum* is the transmitter of verruga peruana (Oroya fever) of the Andes.

Phlebotomus Argentipes.—This is of medium size having the head and abdomen of a brown colour, and the dorsum of the thorax dark brown or blackish in colour, with yellowish sides. The lower parts of the legs are silvery white; hence the name. The antennæ and palpi are grey. It is found in all the places where kala-azar is prevalent. It is not observed at an altitude of 2,000 feet above the sea level. Its development depends on high atmospheric humidity and moderate steady temperature. The high subsoil water level and alluvial soil help the maintenance of the necessary humidity throughout the drier months of the year. The rainy season is naturally, therefore, the most suitable for its breeding. The most favourable conditions for its breeding are found in old villages surrounded by vegetation especially around thick mud walled huts, where the soil has been thoroughly saturated with animal pollutions. In towns they are generally found in dwellings which are surrounded by uncovered earth, especially when this is enriched with fowls' droppings.[1] It has a very feeble power of flight, and is rarely seen on the upper stories of buildings. It is also not carried on the body of man or in his luggage. Hence its extent of range is very limited.

P. argentipes is only short lived, but it probably passes on the infection to the larval stage of the next generation. The gut of this insect is a very suitable medium for the development and culture of the parasite of kala-azar. In

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1. L. E. Napier, Epidemiological consideration of the Transmission of Kala-azar in India, Ind. Med. Research Memoirs, No. IV., Feb. 1926, p. 219.

addition to *P. argentipes* it is possible that *P. papatassii*, and *P. minutus* may carry kala-azar.

Prophylaxis.—Complete segregation of all recognised cases with their families, combined with thorough disinfection of quarters, clothing and furniture.

The most important measure to be adopted is to protect the sick and healthy against the bites of sand-flies, especially *P. argentipes*. Sleeping at night under an ordinary mosquito net will not do, as the sand-flies are capable of passing through such netting. But it may keep away these insects, if it is sprayed with some odourous oil such as anise oil or eucalyptus oil or a one per cent. solution of formalin. A net made of muslin cloth is effective, but it will be too hot to sleep under it in summer. A net with a mesh of twenty-two holes to the linear inch was found effective in keeping out the minute flies during the last Great War. The net should be carefully tucked in under the mattress. As a further precaution repellent ointments made of some essential oils may be applied to the skin. Powdered camphor sprinkled on the bed also repels these insects. Electric fans will also prevent them from coming near the bed, as they cannot stand strong currents of air. It is advisable to keep the patients in the second floors of the buildings, as the flies are incapable of flying higher than ten feet.

The breeding places of the flies should be destroyed. The rubbish should not be thrown about the locality, but should be collected in a receptacle and burned. The cellars, latrines and dark rooms of the house which are usually the resorts of these insects during the day should be fumigated with sulphur, or sprayed with formalin or cresol. The drains and cesspools should be similarly treated. The cracks in the walls should be filled in with coal tar or cement.

PHLEBOTOMUS FEVER.

Synonyms.—Sand-Fly Fever, Three-Day Fever, Papataci Fever.

This is a specific disease, characterized by high fever,

marked nervous symptoms and pains in the bones and joints. The fever usually subsides on the third day, but often lasts four or five days. The disease does not cause any mortality, but incapacitates the patient to work for a week or ten days.

The disease occurs in the subtropical and tropical countries. In India it is prevalent in the North-Western Frontier Province, and the Punjab. It is known to have occurred as far east as Lucknow and as far south as Bombay. It is found in the Chitral valley and occurs at Quetta at an altitude of 5,000 feet above the sea level. During the last Great War the disease was very prevalent in Egypt, Palestine, Macedonia and Mesopotamia.

Aetiology.—The causative agent of the disease has not yet been discovered, but it is an ultramicroscopic and filterable germ which is present in the peripheral blood of patients suffering from the disease only during the first 24 hours McCombie Young, Richmond and Brendish[1] carried out investigations in North-west India where the disease is very prevalent, but failed to confirm the observations of Whittingham on *Leptospira* as the possible causative agent, and could find no such organism.

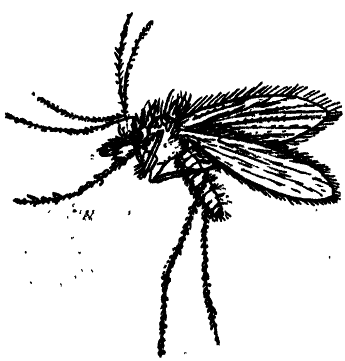

Fig. 68—Phlebotomus Papatassii (Female).

Mode of Infection.—Phlebotomus fever is transmitted by the bite of the sand-fly, *Phlebotomus papatassii.* The sand-fly becomes infected, only if it sucks the blood of a patient during the first 24 hours of illness. It becomes infective about a week or ten days after ingesting the virus. During this period the organism, whatever it may be, undergoes development in the sand-fly.

1. Ind. Jour. Med. Research, April, 1926, p. 998.

Phlebotomus Papatassii.—This is a species of the genus *Phlebotomus*. It is a very minute and hairy insect, abounding largely in the regions, where phlebotomus fever is endemic. In the North-western parts of India this sand-fly is found at an altitude of 5,000 feet, but in the eastern parts of India it is not found above an altitude of 2,000 feet; hence phlebotomus fever probably does not occur above this level. This is probably due to the fact that the Western mountains of India are little affected by the monsoon in comparison with the Himalayas of the more eastern parts, and therefore a hotter and relatively less humid atmosphere which is more congenial to *P. papatassii* is found at higher altitudes of the North-western regions.[1] The female fly lays its eggs in crevices in brick or stone walls, in dark cellars, in caves, in heaps of stones, bricks, and in the surface of the soil. It passes the winter in a larval stage, and the fever is, therefore, met with in summer and early autumn. The female bites chiefly at night. During the day time it is found sheltering in dark corners of the room or behind pictures, almirahs, etc. It is possible that other species of the sand-fly, viz., *P. minutus*, *P. major* and *P. perniciosus* may also convey the disease.

Incubation Period.—This varies from three to seven days. An attack produces immunity, though a second attack is often seen, but of a milder type.

Prophylaxis.—The following preventive measures should be adopted :—

1. The sick should be isolated and the infected quarters should be evacuated and thoroughly disinfected.

2. As a measure of personal prophylaxis McCombie Young, Richmond and Brendish[2] recommend the use of a house net made of muslin, covering an area of 7 feet by 8 feet

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1. Major J. A. Sinton, I.M.S., Notes on some Indian Species of the Genus Phlebotomus, Indian Jour. Med. Research, April, 1925, p. 701.

2. Ind. Jour. of Med. Research, April, 1926, p. 1008.

and 7 feet high, suspended over a frame of 12 male bamboos held together by 8 metal corner pieces, inside which is the bed of the user, and an electric table fan.

The bottom of the net is made of cotton and weighted with shot along its edges to ensure contact with the floor. It is desirable to have the bottom of the net somewhat wider than the top.

CHAPTER XXI.

HOOKWORM DISEASE, LEPROSY, RABIES AND ANTHRAX.

HOOKWORM DISEASE.

(ANKYLOSTOMIASIS, UNCINARIASIS OR MINER'S DISEASE).

THIS is a widely spread disease, occurring in all tropical and subtropical countries. In India it is prevalent in Assam, Bengal, Madras and Ceylon, to some extent in the United Provinces and slightly in Burma and north-west Provinces. It is not known in cold countries, except in deep mines and brickyards where the conditions of heat and moisture are favourable for the development of the disease.

Aetiology.—The disease is caused by a hookworm, a parasitic nematode (round worm) belonging to the supra family *Strongyloides*. It inhabits the small intestine of man, particularly the duodenum and jejunum, where it sucks blood. There are two species of the hookworm, *viz.*, 1. *Ankylostoma duodenale* discovered and described by Dubini in 1843. It is also known as the Old World hookworm as it was supposed to be more prevalent in the regions of the Old World. 2. *Necator americanus* (*Uncinaria americana*) discovered by Stiles in 1902. It is also called the New World hook worm, as it was found to be very common in the New World (America). However both these species are now known to occur in both hemispheres.

Ankylostoma Duodenale.—It has a cylindrical body in both sexes, and a white or grey colour which becomes reddish brown when gorged with blood. In the mouth are situated two pairs of chitinous hooklike teeth on its ventral surface close behind the orifice and one pair on the dorsal surface. The anterior part of the body is occupied in both sexes by two head glands, which secrete a ferment that prevents the

clotting of blood. The male worm is smaller than the female, the former being 8 to 11 mm. long and 0.4 to 0.5 mm. broad, and the latter 10 to 13 mm. long and 0.6 mm. broad. The male is provided at the tail end with an umbrella-like expansion, known as a caudal bursa. The male uses this bursa for holding the female during copulation. In the female the vulva is situated at the junction of the middle and hinder parts of the body, from which a short vagina opens into the ovary and uterine tubes.

Necator Americanus.—This is shorter and more slender than *Ankylostoma duodenale*, the measurements being 7 to 9 mm. in length and 0.3 mm. in breadth in the male and 9 to 11 mm. in length and 0.4 mm. in breadth in the female. The buccal capsule is smaller than that of *A. duodenale*, and is provided with a ventral pair of semilunar chitinous plates in place of the four ventral hooklike teeth and a dorsal pair of slightly developed plates in place of the pair of dorsal teeth. The opening of the dorsal head gland projects prominently into the floor of the buccal cavity, and appears like a dorsal conical tooth. One pair of dorsal and one pair of ventral submedian lancets are situated deep in the buccal cavity.

Life-History.—The life-history of these two species of hookworm is identical and for practical purposes it is not necessary to consider any distinction between them. They should be treated as one.

The fully developed hookworm lives in the small intestine of man, especially the duodenum and jejunum. It attaches itself to the mucous and submucous membrane of the intestinal wall, from which it sucks blood for its nutrition and eats the epithelium. It shifts from place to place giving rise to secondary hæmorrhages. It is also supposed to produce a toxic substance which has an injurious effect on the red blood corpuscles of the host and produces marked anæmia.

Copulation takes place between the male and the female in the intestinal canal, and the fertilized female discharges a large number of eggs almost in a continuous stream into the

intestinal canal. The eggs are ellipsoidal and are about $\frac{1}{400}$ inch (60 microns) long and $\frac{1}{700}$ inch (35 microns) in breadth, those of the American variety being slightly larger than those of the Ankylostome variety. The eggs do not develop in the intestinal canal, but pass out in segmentation with the fæces. Under favourable conditions of oxygen, warmth and moisture the eggs are hatched in the soil, liberating rhabditiform larvæ in twenty-four to forty-eight hours. The newly hatched needleshaped larvæ are less than one hundredth of an inch in length, and are provided with a long cylindrical mouth opening into a bottle shaped œsophagus and a straight simple intestine opening into an anus, but they have no reproductive organs. They are very active, live in hot, moist soil, and feed on the fæcal matter. The larvæ pass through two ecdyses or moults in about a week or ten days. They now measure about one-fiftieth of an inch in length, are capable of living a free parasitic life and are ready to infect man. They continue to live encysted in the discarded skin of the second ecdysis, which is left behind when they pierce the skin of man. In this condition they may continue to live in moist earth for months (14 weeks according to Mhaskar[1]) feeding on the food material stored up in the cells of their intestines. It is said that they are able to traverse long distances in the soil if there is even a trace of moisture and may thus increase the radius of soil pollution. But according to Mhaskar[1] the larvæ are not found in places away from the nightsoil, nor are they to be seen below the bottom level of the nightsoil. The larvæ are very resistant, and are not affected by sunlight, but are destroyed by high temperature, loss of the encasing sheath or complete desiccation. The period from the hatching of the eggs to the development of the larvæ to a mature stage when they are ready to be transferred to a host is usually a week.

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1. Indian Journal of Medical Research, Vol. XI, 1924, p. 951.

Modes of Infection.—Infection takes place by the mouth or through the skin. The mature larvæ may be swallowed with infected muddy water, vegetables, fruits or other articles of food, or from dirty contaminated fingers. It is, however, a controversial point if the infection occurs at all by the mouth. If it occurs at all it is a very rare event.

The usual method of infection is through the skin. The mature larvæ can readily penetrate the unbroken skin through the hair follicles and in most cases enter the body through the bare feet while walking on moist infected ground. Inflammatory reaction occurs at the seat of the lesion giving rise to dermatitis, irritating papules, vesicles, pustules or ulcers, and is known as ground itch, *pani-ghao*, toe-itch, mud-itch, water-pox, water sores, etc. Loos has shown by experiments that after penetrating the skin the larvæ bore through the sub-cutaneous tissues and enter the blood stream through the lymphatics and venous blood vessels. They are then carried to the right side of the heart, and thence to the lungs. Being unable to pass through the small pulmonary capillaries they enter the bronchial tubes through the air vesicles. From the bronchi they pass into the trachea and then into the throat, from where they are swallowed into the stomach, where they are not, in any way, affected by the gastric juice. Passing out of the stomach they finally lodge in the duodenum and jejunum of the small intestine. In the intestinal canal they undergo two further ecdyses or moults before they develop into fully grown worms. The cycle of development in the human body varies from four to six weeks. Owing to the readiness with which reinfection occurs in the same individual it is difficult to determine how long the hookworms can live in the intestinal tract, but it has been estimated that they may live for months or years (one to three years according to Sonsino). The worms become sexually mature in three to four weeks, when the fertilized female begins to lay eggs which are discharged in the fæces.

Prevention.—A vigorous anti-hookworm campaign is

necessary to eradicate the disease from factories, tea estates, plantations, mines and rural areas where the disease is very prevalent, as it causes a great economical loss to the country by rendering wage earners physically unfit to carry on sustained work. The disease also retards the physical and mental growth, lowers the vitality and predisposes to other infectious diseases, such as tuberculosis, and adversely affects the birth rate. The campaign generally consists in the appropriate treatment, prevention of soil infection and education.

Treatment.—Appropriate treatment consists in the administration of the drugs which will kill and expel the worms from the intestine. The chief drugs that are recommended for this purpose are thymol, oil of chenopodium, carbon tetrachloride, Beta-naphthol and oil of eucalyptus.

Owing to apathy of the people in seeking medical aid municipal boards in towns and cities and district boards in rural areas should employ a staff consisting of a qualified medical man, compounder, and one or two other assistants whose duty should be to visit the people in their homes and collect the stools to be examined microscopically, and if the stools are found infested with the hookworm parasite, arrangement must at once be made to treat those cases. By this method persons suffering from the disease as well as the hookworm carriers, *i.e.*, those who pass eggs in the fæces, but do not show any symptoms of the disease, will all be treated simultaneously. In this connection it should be remembered that no one should be pronounced as cured till the fæces do not show any ova on repeated microscopic examinations for two or three weeks after the last dose of medicine. Coolies and agricultural labourers migrating from infected localities should be isolated and treated similarly.

Soil Infection.—The prevention of pollution of the soil by the fæces of infected persons is the most essential factor in the eradication of hookworm disease. It is, therefore, very essential that the people must not be allowed to use open spaces for the purpose of defæcation near their huts on tea

estates, factories, mines or near their villages, fields, etc. They must use sanitary privies and latrines specially provided for them. These must be far away from the sources of water-supply and at a reasonable distance from habitations, and must be properly screened so as to be protected from animals, creeping and crawling things and flies. A sweeper must be kept on the premises and should see that the privy pans do not overflow and the excess reaches the soil. The pans should be emptied into receptacles in such a manner as to avoid the fæces falling on the soil to pollute it. The nightsoil should then be buried deep in the earth, emptied into a sewer or burned in an incinerator. It is not necessary to suggest which latrine will be the best. This can be found out by persons from their own experience to suit the local conditions and requirements having regard to the habits and customs of the people with whom they have to deal. Trench latrine, Aqua privy and Bailey's patent manufactured by the Empire Engineering Company of Cawnpore have been found to serve the purpose in many places in India. The pit system has also worked very well when the people using them are not very intelligent, but the pits should be dug deep in the earth, and the contents should be daily covered with lime, dry earth, or some other drying material.

Infection very often occurs while standing on an infected site during defæcation. Hence Asa C. Chandler[1] recommends that a layer of thatch six inches deep be spread over the area as it effectively prevents contact with hookworm larvæ developing from stools deposited on it even under the most favourable conditions.

Education.—This is one of the most effective and important factors in controlling the spread of the disease. Education on the subject may be spread among the infested community by the issue of pamphlets in the vernacular languages, by the publication of articles in the local press, and by lectures and lantern demonstrations by medical men.

1. Indian Journal of Medical Research, Oct. 1925, p. 407.

LEPROSY.

Leprosy is a chronic infectious disease, associated with characteristic lesions of the skin, mucous membranes and nerves. The disease occurs in two varieties—the nodular or tubercular, involving the skin and subcutaneous tissues and producing nodular swellings especially on the face and ears, and the anæsthetic, involving the nerves and producing anæsthetic patches and a large variety of trophic changes. These varieties often exist together.

Leprosy is one of the oldest of known diseases, and is still widely distributed over all tropical, subtropical and temperate regions There is no race which is wholly free from it. In India it is estimated that there are some 500,000 lepers. In China, Japan and Egypt the disease has existed from ancient times. It has spread to southern Africa, where it is on the increase. During the middle Ages the disease was very prevalent in Europe, but owing to the improvement in general sanitation and the standards of living it has become almost extinct from most of the countries except from Greece, Turkey, Norway, Russia and Iceland. In America it exists in the Gulph States and Mexico. It has been for long endemic in the West Indies.

Aetiology.—The causative agent of leprosy is the *Mycobacterium lepræ* or *Bacillus lepræ*, discovered by Hansen of Bergen in 1874. It is a long, slender, rod-like, non-motile and acid-fast bacillus, which has many points of resemblance to the tubercle bacillus. It is often found lying together in dense clusters, described as "cigar bundles," and these are larger and in greater numbers within the ovoid cells (lepra cells) than those of the tubercle bacillus. The lepra bacillus has not been cultivated outside the human body, and direct inoculations have so far proved unsuccessful. This bacillus is also likely to be confounded with *Bacillus smegmæ*, a non-pathogenic organism. These three organisms are capable of retaining carbol fuchsin stains, after they are washed with mineral acids.

The lepra bacillus is generally found in the nasal discharges, the initial lesion in most cases being an ulceration of the nasal septum. It is also found in the nodular lesions of the skin and mucous membrane, in the nerve sheaths, and in the lesions of the liver, spleen testicles and lymphatic glands. It is very rarely found in the lungs or spinal cord. It leaves the body from any of the lesions that are broken down and become ulcerated.

Leprosy occurs between the ages of ten and thirty years. It is extremely rare before the fifth year, though a few exceptional cases are on record where it infected children of one and two years of age. It generally does not attack persons over forty years of age, although cases have been recorded in which the disease occurred upto or even after the age of seventy. It is much more common among men than women. At the International Conference on leprosy at Bergen in 1909 Sir Jonathan Hutchinson suggested that the disease was due to the excessive consumption of stale and badly preserved fish, but the suggestion is now discredited. It is, however, true that a diet which is deficient in vitamins which are so necessary for the maintenance of the resisting power of the body to the invasion of the infectious diseases acts as a predisposing factor for the attack of this disease. Diseases, such as syphilis, malaria, gastro-intestinal diseases, and intestinal parasites are also the predisposing causes of this disease.

Damp, hot climates with a high rainfall, defective and overcrowded houses, uncleanly habits, squalor and poverty are probably the chief conditions which favour the prevalence of the disease.

Period of Incubation.—This is not known, but it is prolonged and may vary from five to ten years.

Mode of Infection.—Leprosy is not a hereditary disease, *i.e.*, a child of the leprous parents is not born with the disease, but it is communicated through the direct or indirect transmission of the lepra bacillus from the diseased

to the healthy, although the exact mode or modes of infection are not yet definitely known. All modern authorities are, however, agreed that the bacillus finds its entrance into the body through an abrasion or wound in the skin or superficial mucous membrane, such as that of the nose. It has been observed in leprous countries that people going about barefooted are more frequently attacked on the feet than those who wear shoes. Infection may also occur by close contact over a prolonged period, such as occupying the same bed with a leper or taking food from the same dish or smoking from the same pipe as used by the leper.

Blood-sucking insects, such as bugs, fleas, lice, mosquitoes, etc., have been suspected of being direct carriers of the infection from the diseased to the healthy, but uptil now experiments have failed to incriminate any of these insects. It is, however, possible that house flies may play an important part in the spread of the disease, by carrying lepra bacilli in their intestines from infected ulcers and depositing them in their excrement on abraded mucous surfaces such as the nasal orifice or cutaneous wounds of healthy persons.

Having found entrance into the body through the primary lesion or lesions the bacilli are disseminated to the most distant parts of the body by means of the lymph or blood stream and by auto-inoculation.

Prevention.—Rogers and Muir[1] recommend the following measures for the eradication of the disease :—

1. Compulsory notification of every case of leprosy immediately it is recognized by both medical men and laymen, under legal penalties for omission.

2. Examination of each notified case by an experienced medical board with the aid of microscopical examinations to confirm the diagnosis, and to decide if the patient is in an infective stage.

3. The immediate isolation—best in a special institution, such as a leper colony or hospital—of every case from which

1. Leprosy, 1925, pp. 126, 127.

lepra bacilli are likely to escape from the nose, throat or skin, the patient being detained until free from all signs of the disease for not less than one year during which repeated bacteriological tests shall have proved negative. The British Empire Leprosy Relief Association has recently been started at the instance of Sir Leonard Rogers. Its main work is to eradicate the disease from British possessions by making provisions for the adequate treatment on modern lines and the segregation of the lepers. As the result of an appeal by His Excellency the Viceroy a large amount of money has been collected in India for anti-leprosy work. A scheme has been prepared to train medical graduates in the diagnosis and treatment of leprosy cases at a central research institute at Calcutta, and then to open out-patient dispensaries in big cities and leprosy hospitals in the different provinces.

4. Where home isolation is allowed, only patients with no discharge of lepra bacilli from their skin and nasal mucous membrane should be permitted to remain in their houses, when their circumstances satisfy the medical inspector that others living in the house incur no danger, and no children or adolescents are residing there.

5. Segregation of the sexes and prohibition of marriages of lepers with healthy persons or with each other unless the male submits first to the operation of sterilization to prevent the procreation of children, or the woman has passed the child-bearing age.

6. The separation of healthy children of lepers from their parents from birth.

7. When a leper is found, all house contacts and close associates should be examined at once, and for three to six months upto five years, to enable new infections to be detected and treated at the earliest moment.

8. All immigrants arriving with leprosy or developing the disease within its full period of incubation should be repatriated.

RABIES.

This is an acute, specific, infectious disease, occurring in dogs, wolves and allied animals, but transmissible to man and other warm-blooded animals. When it occurs in man, it is called "hydrophobia" from the dread of water, which is one of the chief symptoms.

Rabies is distributed all over the world. In India it is very common in jackals, which form a chief source of infection to pariah dogs loitering about the lanes and streets in villages and towns. The dogs convey infection to man and other domesticated animals, such as cows, buffaloes, horses, donkeys, etc.

Aetiology.—The causative agent of rabies has not yet been definitely identified. It is a filterable virus, and occurs chiefly in the saliva, central nervous system and medulla of an infected animal. It is destroyed at 55° C. in 30 minutes. It is not affected by glycerine, which is, therefore, used as a preservative when the brain of a suspected animal is sent to the laboratory for examination.

In 1903 Negri, of Pavia, described certain round, oval, or angular bodies as occurring in the nervous system of animals suffering from rabies. These bodies, which are popularly known as Negri bodies, have since been studied by Williams, Lowden and Calkins who have given them the scientific name, *Neurorrhyctes hydrophobiæ*. They vary from 1 to 23 microns in length, and are found in large numbers in the pyramidal cells of the Cornu ammonis and the cerebellum of the affected animal. Their exact nature is not known. They are regarded by some as causative organisms of the nature of protozoa, and by others as products of degeneration of the nuclei of nerve cells by the virus. It is an established fact that these bodies are found only in rabies and in neither the healthy condition nor in any other disease. They are, therefore, of great value in the diagnosis of the disease. It should, however, be remembered that owing to their minute size in the early part

of the disease they are not likely to be detected in infective parts of the nervous system, if the rabid animal is not allowed to live until death. They are also not found in deaths from inoculation of "fixed virus".

Mode of Transmission.—The disease is transmitted by inoculation of the infected saliva into the skin through the bite of a rabid animal. It may also be spread by the licking of an infected animal, if there is an abrasion or wound in the skin or mucous membrane. The virus is harmless, when swallowed by the mouth, provided the mucous membrane is in tact. The gastric juice has decidedly a deleterious effect upon the virus.

The virus enters the system through an abraded surface of the skin or mucous membrane, and follows the nerve trunks from the seat of injury to the spinal cord, thence to the medulla and brain. From the brain it passes into the salivary glands and thence into the saliva. It is said that the saliva of human beings and herbivorous animals suffering from this disease contains practically no virus, and is not, therefore, considered infective, but it is not always so. At any rate the saliva of herbivorous animals is capable of transmitting the disease under certain conditions. Lieut.-Col. J. Cunningham, I.M.S., reports the case of a mason who developed hydrophobia eight months after having been licked by a rabid buffalo, and died two days afterwards in hospital at Lahore.[1]

Incubation Period.—The period of incubation in the dog is from three to five weeks on an average after infection, although it is very variable. There are two forms of canine rabies, *viz.*, furious rabies and dumb or paralytic rabies.

Furious rabies is divided into three stages: 1. the stage of depression, 2. the stage of frenzy, and 3. the stage of paralysis. The first stage is marked by excitability, irritability, restlessness, distrustfulness and capricious appetite, as the dog eats any kind of rubbish or dirt, and even its own filth. There is often abnormal itching at the site of the wound produced by the bite.

1. Ind. Med. Gaz., Oct., 1927, p. 599.

This stage generally lasts for two or three days, and is perhaps the most dangerous, as the symptoms are not very suggestive. This is followed by the second stage which is characterized by attacks of maniacal fury and convulsions. Excitement and irritability are much more marked. Illusions and hallucinations are evident and the dog has a tendency to run about aimlessly. During its flight it attacks and bites any object, animate or inanimate, that comes in its way. This stage lasts for three or four days and is succeeded by a stage of paralysis. In this stage there is much emaciation followed by paralysis.

Paralysis usually starts first in the hind legs, and then gradually spreads to other muscles of the body. The bark loses its ring and becomes hoarse. Swallowing becomes difficult. There is drooping of the lower jaw with the accumulation in the mouth of ropy saliva which the animal vainly tries to scratch away with its paw. Lastly after partial or general convulsions death occurs from asphyxia between the fifth and tenth day.

In dumb rabies the first and second stages are generally absent, and paralysis supervenes from the beginning. Death occurs much more rapidly in two or three days.

The period of incubation in man is extremely variable, depending upon the proximity to the brain of the part of the body bitten, and the quantity and virulence of the virus inoculated. The average period is six weeks, but according to Horsley it may be as short as six days or as long as two years. R. A. Saran has noted 3½ months as incubation period in one case.[1]

Prophylaxis.—This is considered under the following headings :—

1. **Immediate Treatment.**—The wound or wounds produced by the bite of an animal known or suspected to be rabid should be at once enlarged, carefully washed and thoroughly cauterized with fuming nitric acid.

2. **Pasteur's Preventive Treatment.**—This is also known as Pasteur's antirabic treatment, as it was first elaborated by Pasteur in 1884. The principle of the treatment

1. Ind. Med. Gaz., Oct., 1927, p. 600.

consists in immunizing the system to the virus of rabies by inoculating an attenuated virus. The method may be described as follows :—

A virus of constant and maximum intensity is first obtained by inoculating subdurally the virus from the central nervous system of a rabid dog or wolf through a successive seriers of rabbits until the animal is killed on the seventh or eighth day. This is known as "fixed" virus as against "street virus" which is the virus obtained from the central nervous system of animals, acquiring the disease in the natural way, and which is of extremely variable strength. The virus contained in the spinal cord or medulla of a rabbit killed by inoculation oft he "fixed" virus is attenuated by submitting it to a drying process in a sterilized glass bell-jar containing some caustic soda at the bottom for a period of one to fourteen days. The virus is thus attenuated and loses all its virulence on the fourteenth day. Individuals bitten by rabid animals are inoculated subcutaneously first with an emulsion of a cord dried for fourteen days, subsequently with cords dried for a less and less number of days, and lastly with a cord dried for three days only. The treatment is followed daily for twenty-one days. Semple has modified this treatment by using the vaccine. It is prepared from an emulsion of "fixed" virus brain and spinal cord in carbolised normal saline solution, the strength being one per cent. of brain substance and 0.5 per cent. of carbolic acid. The vaccine should be kept in cold storage. 5 c.c. of the vaccine are injected daily into the abdominal wall for fourteen days. This method of treatment is now adopted at the Pasteur Institutes of Kasauli, Shillong, Coonoor and Rangoon in India. It is also available at Parel (Bombay), Poona, Ahmednagar, Belgaum, Ahmedabad, Karachi, Allahabad and many other places.

Judging from the results hitherto obtained this treatment has been found very efficacious. In 1921 the percentage of failures was only 0.5 out of 8,000 treated at the Pasteur Institute, Kasauli. It is therefore incumbent on every

medical man and sanitary authority to persuade people bitten by rabid animals to go to the nearest Pasteur Institute for preventive treatment. Government pay all expenses including railway fare to their low-paid servants and to all poor people. Municipalities and other local bodies also pay expenses to their servants.

In all cases of bites by rabid animals this preventive treatment should be adopted as early as possible. In doubtful cases the dog inflicting the bite should not be killed at once, but should be kept under observation in safe custody. If it is rabid, it will develop definite symptoms of the disease within a few hours, or a couple of days, and will die within ten days. Then its brain should be taken out, divided longitudinally, and one half should be preserved in 50 per cent. glycerine, and the other half in Zenker's fluid consisting of 2.5 grammes of potassium bicarbonate, 1 gramme of sodium sulphate, 5 grammes of mercuric chloride, 5 c.c. of glaceal acetic acid and 100 c.c. of water. These halves of the brain should then be sent to a nearest Pasteur Institute for examination. Acton and Knowles have found by making investigations at Kasauli Institute that the saliva is never infectious earlier than 72 hours before definite symptoms appear and that they are of opinion that "if the biting animal remains alive and well for ten days after biting a human being, the saliva cannot have been infective and treatment in such cases is not necessary".

3. **Control and Eradication.**—Rabies can be stamped out by destroying all ownerless and stray dogs by drowning or asphyxiating them in a lethal chamber, and muzzling all known dogs for a sufficient length of time, *viz.*, two years. But in a country like India, where the majority of people have great scruples against taking away the life of an animal or even an insect, however dangerous it may be to human beings, it is not possible to carry on wholesale destruction of stray dogs. It is, therefore, advisable to desex or sterilize such dogs. The operation is simple and painless, if performed by an experienced veterinary surgeon under proper precautions. If this is

objectionable on sentimental or religious grounds, the next best thing is to collect and keep dogs and bitches quite separately in *pinjara pols* or some other places, from where they cannot escape.

Municipalities and District Bodies should levy a tax on people who keep dogs on their premises, and should enforce a rule that such dogs should wear a collar and should be muzzled day and night. By adopting the system of muzzling and imposing a quarantine on imported dogs for six months England was freed from rabies in 1902, and not a single case occurred in man or animal till 1918, when rabies developed in a few dogs, as an infected dog was allowed to enter the country without undergoing a quarantine owing to the slackness in the observance of the rules during the last Great War.

ANTHRAX
(SPLENIC FEVER, CHARBON, MALIGNANT PUSTULE, WOOL-SORTER'S DISEASE, AND SPLENIC APOPLEXY).

This is an acute infectious, highly fatal disease, which occurs primarily in nearly all herbivorous animals, and is secondarily communicated to man. It is widely distributed all over the world, though it is more prevalent in Russia, Siberia, Asia Minor, Persia and China. It is comparatively rare in India.

Aetiology.—The disease is caused by *Bacillus anthracis*, a non-motile, rod-shaped organism, generally presenting square ends. It is one of the largest of the pathogenic organisms, measuring 5 to 20 microns in length and 1 to 1.5 microns in breadth. It is found in the blood and internal organs of an infected animal or man. Very often several bacilli are found lying attached end to end within a common sheath or capsule, which acts as a protective to them against the destructive action of the body cells. The bacillus grows best at or near the blood-heat. It is classed as an ærobic organism, as it grows and multiplics only in the presence of air. Spores are not formed, when the bacillus is in the living

tissues, but will develop rapidly, after it is discharged from the tissues and is exposed to the air. The spores are found in the hides, wool and hair of diseased animals and also in the soil.

The anthrax bacillus is readily destroyed by boiling for a few seconds, or by immersion in a 1 per cent. solution of carbolic acid for two minutes. But its spores are very resistant, and are not affected by an immersion in a 1 per cent. solution of carbolic acid for a week or even a prolonged immersion in alcohol or a 5 per cent. solution of carbolic acid. They are destroyed by continuous exposure to dry heat at 140° C. for three hours. Virulent spores have been found in the soil after 15 years.

Modes of Infection.—The bacillus of this disease may gain entrance to the animal body through an abrasion or wound in the skin or mucous membrane to the blood, through ingestion of contaminated food to the alimentary canal or through inhalation of the spores to the respiratory system. Some times animals may be directly inoculated with the infective virus by the bite of the stable fly, *Stomoxys calcitrans*, and *Tabanus striatus*. Occasionally herds or flocks of cattle are infected through a slight wound in the mouth, pharynx or œsophagus by swallowing infected grass growing on the pasturage, which has been contaminated with the discharges of an animal suffering from the disease. Pasteur has held that earth worms play an important part in conveying the bacilli to the surface from the carcass of an infected animal buried superficially.

In man the disease may be conveyed by direct inoculation through an abrasion or wound in the skin, when malignant pustule forms on the neck, face, hand, forearm, arm or any other exposed surface. It may be conveyed to the lungs through inhalation of dust containing anthrax spores, when constitutional symptoms appear, indicating general infection which usually proves fatal in the course of a very few days. This form of the disease is known as "pulmonary anthrax" or "wool-sorter's disease". Infection may also result from eating

diseased meat, drinking milk obtained from a diseased animal, eating fruit and vegetables contaminated by the discharges of affected animals, when the lesions are produced in the intestine.

Anthrax infection in man is mostly an industrial disease, and occurs among wool-sorters, tanners, sheep shearers, and butchers.

A few cases of anthrax have recently occurred from the use of shaving brushes made from infected horse-hair.

Prevention.—Animals suffering from the disease must be isolated, or, better, killed. The discharges of infected animals must be destroyed. The carcass of an animal dead from the disease should not be opened and exposed to the air, but should be immediately burnt. If this is not possible, the entire carcass should be buried in quicklime at a depth of six or seven feet from the surface, and the place should be fenced in so as to prevent other animals grazing over it.

Animals are rendered immune by a subcutaneous injection of Pasteur's weak vaccine of attenuated non-sporing anthrax bacilli cultures, and ten or twelve days latter by a second injection of a stronger vaccine. Immunity commences about two weeks after the second vaccine has been administered, and lasts for about a year.

Sclavo's anti-anthrax serum is used in the treatment of the disease in man. It is prepared by immunizing asses or goats with Pasteur's vaccine followed by injection of increasing doses of virulent cultures. The dose is 20 to 40 c.c., repeated in 24 hours, if necessary. In severe cases it is administered intravenously. As a prophylactic it may be used in small doses of 2 to 2.5 c.c.

Shaving brushes should be soaked for four hours in a ten per cent. solution of formalin, a 1 in 1,000 solution of mercuric chloride, or a 1 in 40 solution of lysol, and then thoroughly and repeatedly washed in hot, soapy water, before they are used for the first time.

CHAPTER XXII.

SMALL-POX, CHICKEN POX, MEASLES, WHOOPING COUGH, DIPHTHERIA AND INFLUENZA.

SMALL-POX (VARIOLA).

THIS is an acute, specific, infectious disease and though endemic in India, China, Egypt and many Eastern countries, it occurs in an epidemic form in all parts of the globe and affects the white as well as the coloured races.

Aetiology.—Discoveries have been made that the causal organisms of small-pox are protozoal bodies, known as *Cytorrhyctes variolæ* or "Guarnieri bodies," which are spherical and homogeneous in structure, have a diameter varying from seven-tenths to three or four microns and are found lying in the protoplasm of the epithelial cells of the pocks, but these have not been confirmed. The only definite fact that is at present known about the causation of the disease is that the organism causing the disease is a living virus which is capable of passing through ordinary bacterial filters.

The disease attacks both sexes of all ages unprotected by efficient vaccination, but is particularly common among, and fatal to, unvaccinated children under five years of age. The fœtus in *utero* may be attacked by the disease, if the mother herself is suffering from it, and the child may be born with the rash or scars upon it. In places where vaccination is common among infants, the incidence of the disease becomes more prevalent among adults after thirty years of age when the effects of vaccination have passed away.

The disease appears to be favoured by cold and retarded by heat. The rainy season puts a check on it. In Calcutta the greatest number of deaths occurs in March, and in Bombay in April.

Mode of Infection.—Nothing is yet known of the exact method by which the infection of small-pox is conveyed; however, the general belief is that it is an air-borne disease and enters the system through the respiratory tract. The virus of small-pox, whatever it may be, is contained in the skin eruptions and in the mouth and throat secretions of the patient, and is capable of being carried down the wind for considerable distances through the air in the dried epithelial scales and pus cells from the crusted pocks.

Infection may also be conveyed by beddings, towels, handkerchiefs, books, toys, spoons and articles of furniture, that may have come into contact with the patient. The poison remains active for a long time on such articles. It is also likely that the house-fly may convey the disease by carrying infection along its proboscis, feet and other portions of its body by first sitting on a sick person and then alighting on a susceptible healthy person.

Incubation Period.—The incubation period is usually twelve days, though it may vary from nine to fifteen.

Infectivity.—The period of infectivity begins with the appearance of eruptions and lasts till desquamation of all crusts has ceased. In some cases the disease is infectious in its initial stage before the eruptions have appeared and even during the stage of incubation. Ordinarily the duration is considered to be 5 to 8 weeks.

Immunity.—One attack of small-pox generally confers immunity on an individual for the rest of his life, but in rare cases second and third attacks of the disease have been noted.

Preventive Measures.—Protection from small-pox can be acquired by (1) Isolation, (2) Disinfection, and (3) Vaccination.

1. **Isolation.**—Small-pox is a notifiable disease by the order of the Government. Hence a patient suffering from the disease should be promptly isolated to an infectious diseases' hospital, if there is no special small-pox hospital.

In India it is a pity that isolation is not strictly carried out. Those who come into contact with the patient must be kept under surveillance for at least 14 days. During this period they should certainly be vaccinated, if not done recently. No harm is done by vaccination during the incubation period. On the contrary successful vaccination performed during the first three days of the incubation period prevents the attack of small-pox, and probably arrests or modifies the attack if performed on the 5th or even the 6th day. The children of an infected house must not be allowed to go to school, lest they might infect the other children of the school.

2. **Disinfection.**—The house occupied by the patient, and the bedding and other wearing apparels, as well as the furniture should be thoroughly disinfected. The clothing of the contacts should also be disinfected. The patient himself is a great source of infection. Hence all his discharges, such as the sputum, urine and fæces should be disinfected with chlorinated lime, that has not lost its chlorine smell by prolonged keeping or with any other disinfecting solution, before they are finally disposed of. He should not be allowed to mix with other people, until desquamation has stopped. This may be favoured by the use of warm baths with soap, and by anointing the skin with vaseline or oil.

3. **Vaccination.**—Vaccination, *i.e.*, inoculation of cow-pox or vaccinia was introduced by Edward Jenner in 1796. He was led to make the experiment from the facts, long observed in dairy farms, that cows were liable to a pustular disease of the udder and teats, which was often accidentally communicated to men and women milking them, and that these persons enjoyed subsequent immunity from small-pox. Conversely, it was observed that those who had small-pox did not catch the disease from the cows. He demonstrated that cow-pox once implanted in the human subject could be continued indefinitely by inoculation from person to person which rendered the practice of vaccination possible.

The Operation of Vaccination.—It is usually performed on the outer surface of the arm at or about the insertion of the deltoid muscle, or on the forearm below the bend of the elbow. The operation can be carried out by a direct method from arm to arm, or from calf to arm, or from stored calf lymph. The skin at the site of the operation must be rendered surgically clean by scrubbing it with soap and warm water, or with warm water and alcohol ; but strong antiseptics should not be used lest they may destroy the efficacy of the lymph. Lately the tincture of Iodine has been very much advocated for painting the skin before the operation, and it was tried in the district of Agra, but with much less success, probably owing to its irritant nature. To render the operation successful, it is necessary to wash away the tincture of Iodine from the skin before lymph is introduced. The vaccinator must render his hands aseptic, and must also sterilize the needle, lancet, or Weir's scarifier, whichever he uses. It is best to pass it through the flame every time he operates. The lymph may be introduced by punctures, by scratches or by gently rubbing into an abraded surface. Scratching should be just sufficient to cause the exudation of a little blood-stained serum. Four scratched patches should be made, each patch being an inch away from the other. Care should be taken that the lymph is allowed to be dried and not wiped out. Dressings or bandages of any sort should not be applied, but some pieces of gauze may be placed over them as a protection.

Age for Vaccination.—Small-pox is a disease of young children. It is, therefore, obvious that there should be no unnecessary delay in vaccinating children. The best time to vaccinate a child is within six months of its birth, before dentition has commenced. If small-pox be prevalent, children should be vaccinated within three days of their birth. In India vaccination should never be delayed beyond the first year of life. By the Vaccination Act of 1880, as amended by U. P. Act II of 1907, vaccination in the notified areas of the

United Provinces of Agra and Oudh is compulsory from the 6th month to the 14th year of age in the case of unprotected boys and to the 8th year in the case of unprotected girls. If the parent or guardian of a child during this period refuses to have it vaccinated without giving satisfactory explanation, he is liable to be punished with a fine extending to 50 rupees for the first offence and with simple imprisonment for a term extending to 6 months, or with fine extending to one thousand rupees or with both for further offences in respect of the same child.

According to this Act, if the superintendent of vaccination is of opinion that a child, which has been three times unsuccessfully vaccinated, is insusceptible of successful vaccination, he shall have to furnish a certificate to that effect to the parent or guardian of such child, who will thenceforth not be required to cause the child to be vaccinated.

Phenomena of Vaccination.—When the operation of vaccination has been successfully carried out on a healthy child, nothing is evident at the site of the operation for the first two days, but by the third day one or more papules appear which are round, flat, red, hard and superficial. On the fifth or sixth day a vesicle forms on the summit of the papule. The vesicle is at first clear and pearl-like, and becomes depressed in the centre as it enlarges. It then becomes surrounded by a deep, red, and swollen areola. On the eighth day the vesicle becomes mature. At this stage it is greyish in colour, tense, elevated and loculated, and contains a clear, viscid lymph, which exudes when the vesicle is pricked, and is used for vaccination purposes. On the ninth day the vesicle becomes pustular, and is surrounded by an inflammatory areola. Constitutional symptoms, *viz.*, malaise, loss of appetite, sometimes nausea and vomiting, headache, pain in the muscles of the back and a slight rise of temperature usually accompany this stage. On the tenth day the vesicle begins to dry up, and forms a dark-brown scab about the 14th day, which falls off usually about the 21st day. The scab should never be removed, as it forms the best form of a

bandage. The scar left after the falling off of the scab remains depressed and pitted.

Immunity of Vaccination.—The immunity conferred by successful vaccination against small-pox appears about the eighth day of the vaccination, and depends upon the efficiency of the operation, and the numbers and character of the vaccination scars. It, however, does not last for life-time, but it wears off gradually with the lapse of time and, therefore, it becomes necessary to practise re-vaccination in order to have continuous protection. The time for re-vaccination is usually between 10 and 13 years of age. After this, it is unnecessary to vaccinate again for the rest of the life, unless the individual is particularly exposed to a danger of small-pox.

The disease has practically disappeared from those countries, *e.g.*, Germany, where vaccination and re-vaccination have been made compulsory.

Value of Vaccination as a Preventive against Small-pox.—In Jenner's time, inoculation of healthy individuals with small-pox matter was freely practised. The disease obtained by inoculation was milder than true small-pox, and was never of a confluent or hæmorrhagic type, while the pustules that appeared were rarely over two hundred.

Inoculation for small-pox was practised in India by Brahmans long before the Christian era. They used to inoculate people in the beginning of the cold season with dried small-pox scabs (attenuated virus) of the previous year. It was then introduced into China, Arabia and other Eastern countries. Lady Mary Westley Montague introduced the method into England in 1721, which was then adopted in America and the continent. The practice of inoculation had the following serious drawbacks :—

1. The disease acquired by inoculation was as highly contagious as true small-pox.

2. Persons coming into contact with those suffering from inoculated small-pox contracted the disease often in a serious or fatal form.

Inoculation, therefore, fell into disrepute, and in 1840 was prohibited by the law in England and other countries. By virtue of the Vaccination Act inoculation is also prohibited in India, and no person who has undergone inoculation is allowed to enter a notified area under the operation of the Act, before the lapse of forty days from the date of the operation, without a certificate from a recognised medical practitioner.

The value of vaccination as a preventive against small-pox was proved by Jenner himself by vaccinating a number of individuals, who did not suffer from the symptoms of small-pox, when they were subsequently inoculated with variolous matter. This value can also be ascertained by comparing the fatal and severe cases among the vaccinated and unvaccinated. In prevaccination times, children suffered most from the disease, and most of them died. The same is the case among unvaccinated people even at the present time. Among the vaccinated, children escape the disease, while adults are liable to be attacked by the disease on account of the fading away of the effects of vaccination performed in childhood, but most of these cases do not prove fatal. Besides, the incidence of small-pox has lowered very much in those towns and cities, where re-vaccination has also been compulsory.

Objections urged against Vaccination.—Anti-vaccinationists oppose vaccination on the ground that it causes several diseases, the chief of which are syphilis, tuberculosis, cancer, leprosy, tetanus, pyæmia, cellulitis, impetigo contagiosa and erysipelas. This allegation is only an exaggeration. If the operation of vaccination is properly performed, no other disease but vaccinia can be imparted. Again, in "arm-to-arm" vaccination, it should be ascertained that the child is healthy, comes from healthy parentage and that it does not suffer from hereditary syphilis or tuberculosis, before the lymph is taken from it. The lymph should be taken only from typical vesicles around which there is no conspicuous commencement of areola. It should also be remembered that a child should not

be vaccinated, when it is very weak and ill-nourished, or suffering from any acute skin disease, from severe diarrhœa or bronchitis, or suffering severely from teething or any other ailment.

The question of syphilis becomes altogether nil, in cases where calf lymph is used, as calves are insusceptible to syphilis. As regards tuberculosis the calves should be watched for at least a week, and should be tested with tuberculin, before they are inoculated with vaccine lymph.

As regards the present reduction in small-pox incidence, anti-vaccinationists attribute it to general improved sanitation, but they are very much mistaken in this, for zymotic diseases, specially those that are air-borne, cannot be said to have been influenced by improved sanitary arrangements, inasmuch as whooping cough and measles have not yet been diminished in spite of improved water-supply, and good and efficient drainage in several big towns and cities.

Varieties of Vaccine Lymph.—These are human lymph fresh from the arm, human lymph dried on ivory points or preserved in capillary tubes; or fresh lymph mixed with glycerine, lanoline or vaseline; or fresh bovine lymph from the calf, bovine lymph dried on ivory points, or preserved in glass tubes, mixed with glycerine, lanoline or vaseline. Preserved glycerinated calf lymph is, now-a-days, used very largely both in Europe and India. Vaccine is removed from the vesicular pulp five days after the vaccination of the calf by means of a sterilized Volkman's spoon, and received into a weighed sterilized bottle. It is then rubbed and triturated in a sterilized glass mortar with a sterilized pestle with six times its weight of a mixture of 50 to 60 per cent. of pure glycerine in distilled water and lastly drawn into large tubes, the ends of which are hermetically sealed by means of a blowpipe. The glycerine has been found to retard or destroy extraneous septic microbes, but not to harm the efficacy of the vaccine. Lanoline paste is somewhat similarly prepared.

Alastrim (Para-small-pox or Kaffir milk-pox).—This is a slightly different variety of small-pox, though it is considered by a majority as a mild type of true small-pox. It occurs as an endemic in West Indies and South Africa, and has occurred in America and other countries. A few cases were reported in Cambridge in 1903 and in various localities on the borders of Norfolk and Suffolk in the summer of 1919. Cases of this disease were noted by Turkhud and Pandit in Madras simultaneously with a severe epidemic of small-pox.[1] The mortality-rate is very low, about 1 to 2 per cent.

The chief preventive measures are the same as in small-pox, *viz.*, isolation of patients, and vaccination of contacts.

CHICKEN-POX (VARICELLA).

This disease occurs in an epidemic form, but sometimes sporadic cases are also met with. It very often coincides with an epidemic of small-pox and adds to the difficulty in diagnosing mild cases of the latter. It is a disease of childhood, and most of the cases occur between the second and sixth years; however, adults who have not had the disease in childhood are liable to be attacked. The specific germ of the disease has not yet been isolated.

The disease is very rarely fatal, and one attack generally confers immunity lasting for the rest of the life.

Incubation Period.—The incubation period varies probably between fourteen and sixteen days.

Mode of Infection.—The infection is conveyed by direct contact or by means of fomites. The patient is infective from the appearance of the first symptoms to the time when all the scabs have dried up. The usual period of infectivity is about 3 weeks.

Preventive Measures.—

(1) Notification of the disease lest some mild form of small-pox may escape notice.

(2) Isolation of the patient.

1. Indian Journal of Med. Research, July 1926, p. 27.

(3) Thorough disinfection of the room occupied by the patient and his clothes and bedding.

(4) Prevention of children living in an infected house from going to school for three weeks.

MEASLES (MORBILLI).

This is a specific, highly infectious, febrile disease, widely distributed throughout the world. It occurs in India generally in cold months from November to April. It is endemic in large cities, and becomes epidemic every two or three years. It attacks children under five years of age, but rarely infants under six months. It also attacks unprotected persons of all ages.

The disease is common in army camps. In the last Great War it caused a very great dislocation in the movements of troops. The incidence of the disease was high among troops enlisted from sparsely populated districts, in which the disease was uncommon and where the local inhabitants had not been exposed to infection previously.

Measles is very fatal to young children owing to pulmonary complications and sequelæ. Overcrowding, poverty and insanitary conditions mostly affect the mortality which is highest in the second year of life.

Aetiology.—The causal agent of this disease has not been identified, but it is a filterable virus, which is present in the circulating blood and nasal, buccal, conjuctival and bronchial secretions of the patient suffering from the disease. The virus outside the body does not live probably more than twenty-four hours.

Modes of Transmission.—The disease is transmitted from the sick to the healthy by means of direct contact through the discharges from the nose and mouth. It may be conveyed indirectly by third persons, and infected clothes or toys. The disease is most infectious in the pre-eruptive stage, and infectivity rapidly declines after the appearance of the rash, which usually takes place on the fourth day after the beginning of the febrile and catarrhal symptoms,

Period of Incubation.—The period of incubation is from ten to fourteen days, though it may vary from eight to twenty days.

Protection.—There is no natural immunity against the disease, but one attack generally confers immunity against subsequent attacks.

Preventive Measures.—It is practically impossible to check the spread of this disease in a community, as it is highly infectious in the preliminary catarrhal period, when diagnosis is difficult.

The patient should be isolated, and the body should be anointed with carbolised vaseline or glycerine. The nasal and buccal secretions should be wiped out with pieces of cloth, which should then be burnt. Clothes and bedding should be disinfected, and so also the room. The children of the house in which a case of measles has occurred should be kept under quarantine, *i.e.*, a strict watch should be kept on them to find out if any other case appears among them. They should not be allowed to mix with the patient, who should be kept separate in a well-ventilated room. They should also not be allowed to go to schools, or meet other children in streets, parks or on play-grounds for at least 3 weeks after eruptions have appeared in the last case in the family.

The following precautions were found to be sufficient to prevent the spread of measles in army huts or billets during the last Great War :—

A thorough examination of the men was made to detect any who appeared to have heavy catarrh or fever; and the examination was repeated in a week's time, and then every day for the next six days to detect any further crop of cases, which might have been infected from the first case, and so to secure early removal of them to hospital. If a case or a simultaneous group of cases of measles appeared in a unit likely to contain a large number of susceptible men, the contacts were segregated for three weeks, or until such time as the men so

isolated had not had a case of measles among them for three weeks.[1]

In order to reduce mortality in measles it is necessary to impress upon the parents that the disease has no bearing on any superstitious belief, and that the infected children should at once be treated on proper medical lines.

The serum of convalescents from the disease has recently been employed as a prophylactic injection. The method appears to have met with some success, and does not appear to be attended by any risk provided the serum is taken from persons who are free from syphilis or tuberculosis.

WHOOPING COUGH (PERTUSSIS).

This is a very frequent and widely spread disease, chiefly affects children under five, and is most fatal to infants, particularly females. It occurs in epidemics which are not, as a rule, influenced by climate or season, though it is more prevalent in cold and damp countries. Race has also no influence over the disease, as both Indian and European children are known to be suffering from it. It generally follows the epidemic of measles.

Aetiology.—The causative organism of the disease is a small bacillus isolated by Bordet and Gengou in 1906. This is closely allied to the bacilli of the influenza group, and is found most readily in large numbers in the sputum of patients during the catarrhal stage and during the first week of spasmodic cough. It is non-motile and Gram-negative, and is obtained in pure cultures when incubated in media containing blood or serum at 37° C. The blood of convalescents from whooping cough agglutinates this bacillus, and gives the complement-fixation test specific for it.

Modes of Transmission.—The disease spreads from one person to another by direct contact or indirectly through clothes, toys, drinking cups, etc., as the virus may cling to

1. Official History of the War, Med. Services, Hygiene of the War, pp. 19, 20.

them, though it is not carried to a long distance. It may also be carried to children through domestic animals, such as dogs and cats, as these are known to be affected by the disease. It is not conveyed through water, food or milk.

Period of Incubation.—The period of incubation varies from 7 to 10 days, but may be delayed up to 14 days, while the period of infectiousness is not less than six to eight weeks from the onset of symptoms.

Protection.—One attack generally affords protection. The second attack is very rare.

Prevention.—The disease can be controlled by isolating the patient in a separate well-ventilated room on the upper storey of a house, if possible, and by disinfecting all the secretions from the nose, mouth and lungs, as well as the articles of clothing and the utensils that may have come into contact with him. The patient should not be allowed to go to school, or to any other public assembly, where other children are likely to collect, and should not be allowed to ride in a public conveyance. The other children of the family should also be forbidden to attend the school, the theatre or any other public place or meeting. Dogs, cats, and other domestic animals should be kept away from the patient, remembering that these animals are susceptible to the disease which may, in their turn, convey it to other children in the street.

The injection of pertussis vaccines as a curative or preventive measure has recently been advocated, but has not met with general approval.

DIPHTHERIA.

This is a specific infectious disease, distributed all over the world, though more prevalent in the temperate regions than in the tropical. It is fairly common in India. It was formerly considered to be a disease of rural districts, but it is now endemic in large cities, and tends to break out in an epidemic form especially in years of deficient rainfall. The epidemic generally occurs in autumn and winter with the

maximum intensity and fatality in October and November or December.

Diphtheria affects both sexes and all ages, but it is especially frequent in, and fatal to, children between two and ten years of age. It rarely attacks newly born infants.

Aetiology.—The disease is caused by the Klebs-Loeffler bacillus, growing chiefly in the pharynx or other portions of the upper respiratory tract and forming a characteristic membrane. This is a non-motile, rod-shaped bacillus, generally straight but sometimes slightly curved, and varying from three to five microns in length and about one-fourth of this in breadth. It has a tendency to be club shaped or segmented. It does not form spores. It is found in the secretions from the mouth, nose and throat, in the shreds of diphtharitic membrane, occasionally in discharges from the eyes, ears, vagina, and rarely in infected wounds or skin lesions.

The bacillus is readily killed by direct exposure to sunlight and heat. It is destroyed within five minutes by a 5 per cent. solution of carbolic acid or a 1 in 1,000 solution of mercuric chloride. However it retains its virulence for a long time, when enclosed in the particles of the dried diphtheritic membrane, or albuminous substances, such as sputum, etc.

The predisposing causes are lowered vitality due to overcrowding and insanitary surroundings and sore-throat, nasal catarrh, laryngitis and unhealthy conditions of the mouth and teeth.

Period of Incubation.—The period of incubation is very short, usually three or four days, but is liable to vary from one to seven days.

Period of Infectivity.—There is no consensus of opinion as regards the period of infectivity, which is laid down between 14 days and 4 or 5 weeks; though as a safeguard, diphtheria convalescents should not be allowed to mix with the healthy until at least two or three cultures taken from the nose and throat are proved negative.

Mode of Transmission.—The disease may be transmitted from the sick to the healthy directly by coughing, speaking, sneezing or kissing, and indirectly through infected articles, such as handkerchiefs, toys, slate pencils, coins, etc. It is conveyed in some cases through contaminated milk and other articles of food. Bacillus carriers play a large role in spreading the disease. It cannot be carried to a long distance by air, as the diphtheria bacillus is frail, and soon dies, when dried or exposed to sunlight.

Immunity.—One attack of diphtheria is not known to confer immunity against subsequent attacks. Immunity may, however, be obtained by the injection of an anti-diphtheritic serum (anti-toxin). The dose for a child under two years is 500 units, and for older children and adults 500 to 1,000 units is the usual dose. The protection thus afforded is known as passive immunity, and is of short duration, three or four weeks only. A second injection of anti-toxin affords a further protection, but it lasts a still shorter time. Hence Von Behring advocates the injection of a mixture of toxin and anti-toxin to induce active immunity, which is far more lasting, though it appears slowly, sometimes in 8 to 12 weeks. Three injections of 1 c.c. are given subcutaneously in the arm at the insertion of the deltoid muscle at intervals of a week to a fortnight. 0.5 c.c. is to be used for children under one year. In cases, where it is suspected that anaphylaxis may develop, a desensitising dose of 0.1 c.c. may be given two days previous to the first injection. This method of active immunisation is particularly suitable in school hostels and orphanages.

The Schick Reaction.—This is a safe and reliable test for determining the presence or absence of the immunity to diphtheria in any individual. A fresh solution of diphtheria toxin is prepared for this purpose of such strength that 0.1 or 0.2 c.c. represents $\frac{1}{50}$th of a minimum lethal dose of toxin for a guinea-pig weighing 250 grammes. This amount is injected intradermically on the flexor surface of the arm or forearm. A positive reaction at the sight of injection shows

the absence of immunity to diphtheria. A negative reaction indicates the presence of immunity.

The positive reaction is marked by a circumscribed area of redness and slight infiltration at the site of injection, which appears gradually, becomes distinct usually in the course of 24 to 48 hours, and reaches its height on the third or fourth day. It slowly disappears leaving a definitely circumscribed scaling area of brownish pigmentation, which persists for three to six weeks.

Preventive Measures.—The most important preventive measures are isolation of the sick and thorough disinfection of the clothing and of everything that has come into contact with the patient. The throats of persons who have come into contact with the patients should be swabbed and examined bacteriologically. If any carriers are found they should be at once isolated and treated with antitoxin. The secretions from the mouth, throat and nose of the patient should be received on a piece of cloth and burnt. During the convalescent stage the mouth, throat and nose should be repeatedly washed with a disinfecting lotion. Doctors and nurses should wash their hands with mercuric perchloride or formalin lotion, and should frequently gargle their throat and mouth with antiseptic lotions. Children from infected houses should not be allowed to go to schools. In the case of an epidemic outbreak, school children should be medically examined, and all cases of sore-throat or nasal catarrh should be segregated and forbidden from attending school until recovery. Those who have been exposed to infection should be examined for Schick reaction, and all those that are found susceptible should be actively immunized by means of toxin-antitoxin mixtures.

INFLUENZA (*LA GRIPPE*).

This is a highly infectious epidemic disease, assuming a pandemic form after five, ten or thirty years, or some intermediate interval, and spreading over almost all parts of the inhabitable world in a very few weeks. The last worldwide

outbreak of 1918-19 first started probably in Spain in April of 1918 and in a short space of time spread over all the continents. The military operations during the last Great War had to account for its rapid spread like a lightning spark. In India it first broke out in Bombay in about June 1918, and then travelled into the interior of the country and infected almost all the towns and villages. It caused a very high mortality of about 6 millions, and disorganized trade to a very large extent. This pandemic was exactly like its predecessor of 1890-91, but the very high mortality during the outbreak was due to the complications of pneumonia, broncho-pneumonia, etc., owing to the lowered vitality of the people from increased poverty and want of proper clothing, especially during the winter season on account of an unprecedented high cost of cloth due to war conditions.

Incidence.—Persons of all ages and both sexes are attacked by the disease, but strong and vigorous, young male adults appear to be more susceptible, perhaps on account of greater chances of exposure.

The disease does not seem to have any relation to season, climate, wind or telluric conditions, but it is much more severe during winter than during summer, as poor people sleep indoors in overcrowded, and dark ill-ventilated rooms, and huddle closely together for want of clothing to protect themselves against cold.

Incubation Period.—The incubation period is very short, from 6 to 48 hours.

Aetiology.—The causal organism of the disease has not yet been definitely established. A large majority of authorities regard the *Bacillus influenzæ* of Pfeiffer as the specific organism causing the disease. This is a small gram-negative, non-motile, rod-shaped bacillus, which grows ærobically at 37°C. as a transparent colony on culture media containing hæmoglobin. It is readily killed by drying, weak antiseptics and a temperature above 60° C. It is found in large numbers in the

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nasal and bronchial secretions of patients suffering from the disease. It is also found in about 30 per cent. of normal throats and is practically always present in measles and whooping cough. Other workers are of opinion that the disease is due to a filterable virus.

Whatever may be the primary cause of the spread of the disease, there is little doubt that the complications are obviously produced by different micro-organisms, the chief of which are the influenza bacillus, pneumococci, and hæmolytic streptococci.

Mode of Infection.—The disease, though spoken of as air-borne, is highly contagious, especially in the early stages. The virus leaves the body in the secretions from the nose, throat, and respiratory tract of infected persons. Hence it is directly spread from the sick to the healthy by "drop infection" as in coughing, sneezing, laughing and even in ordinary conversation. Freshly infected towels, handkerchiefs, cups and other objects also convey the disease. But the virus dies out readily outside the human body, so that infection is not carried to long distances by means of infected clothing. Bacillus carriers are numerous, who keep alive the infection during an inter-pandemic interval. It is possible that the disease may be conveyed through domestic animals, who also suffer from this disease.

Immunity.—No one seems to enjoy a natural immunity, at any rate when the virus is in its pandemic stride. One attack does not confer immunity, as subsequent attacks are common as a result of new infections or reinfections.

Preventive Measures.—It is very difficult to control the spread of the disease by suggesting any preventive measures, inasmuch as the disease spreads very quickly, the incubation period is extremely short, it is infective in its earliest stage, and many mild cases, though capable of conveying infection, may escape detection owing to the difficulties of diagnosis.

Notification of the disease is practically useless, except that it will furnish the statistical information to the health authorities. Isolation of patients, particularly those with pulmonary complications, is a measure worthy of adoption, but it is fraught with practical difficulties in a country like India, where a large population is still steeped in ignorance and superstition. However, it must be impressed that the patient should at once take to bed in a well-ventilated room or, if possible, on an open verandah, as soon as he finds that he is feeling out of sorts during the pandemic wave, and should remain there for a day or two after the temperature has become normal. The patient should always hold a handkerchief to his mouth when he is talking, sneezing or coughing, and the handkerchief should, then, be disinfected by boiling, or burnt, if made of paper. Expectoration should be received in a special vessel, its contents being subsequently disinfected or burnt. Clothing and other articles soiled by the discharges from the mouth and nose should be properly disinfected. It is hardly necessary to disinfect a house in which a case of influenza has occurred, but the room occupied by him should be disinfected. During the epidemic it is also advisable to disinfect public vehicles and railway carriages with a formalin spray.

As a personal prophylactic measure it is much better to avoid churches, crowded railway carriages, tram cars, theatres, cinemas and public meetings, where large assemblies of people congregate together. Fairs and markets should be stopped in villages, where they form a chief source of transmission of the disease. Similarly schools should also be closed.

The wearing by the people of masks of several folds of gauze covering the mouth and nose during the epidemic is a counsel of perfection, but it is not likely to be universally adopted. However, doctors, nurses and other attendants on the sick must wear them to prevent inhalation of infected material directly from the patient.

During the epidemic the people should gargle their throat and lavage the nostrils with mild disinfectants, such as solutions of potassium permanganate, resorcin, thymol, chlorinated soda, etc. A spray of a 1 in 1,000 solution of acro-flavine can also be used as a preventive. It has, however, been suggested that the natural resisting power of the mucous membranes of the nose and throat may be lowered owing to the vital injury caused by such lavage. Hence the Sanitary Commissioner (now Director of Public Health) with the Government of India recommends that the nasal cavities and throat should be douched with a salt solution four or five times daily as a preventive of influenza. The method of douching is as follows:—

1. Dissolve one teaspoonful of salt in a pint of warm water.

2. Gargle the throat with some of the solution.

3. Place the remainder of the solution in a basin.

4. Immerse the nostrils in the solution.

5. Sniff slowly some of the solution up the nostrils, until it is felt at the back of the throat.

6. Raise the head from the basin and allow the solution to flow from the nostrils into a bucket.

7. Repeat this process two or three times.

From investigations carried out in an industrial district, Dr. Alexander Gregor has proved that inhalation of SO_2 or NO_2 acts as a preventive of influenza. People working in an atmosphere containing either of these gases obtain a marked degree of immunity during the outbreaks of influenza.

The use of vaccines has been advocated both as a preventive and curative measure. A polyvalent vaccine consisting of killed cultures of the Pfeiffer's bacillus, pneumococci and streptococci, and a monovalent vaccine consisting of Pfeiffer's bacillus alone have been tried, but the opinion as to their efficiency is still divided. In October 1918 a committee of bacteriologists met at the War Office in London under the chairmanship of Sir William Leishman, and recommended a

prophylactic vaccine of the following composition for general use in the army :—

Bacillus influenzæ	...	60 millions	in 1 c.c.
Diplococcus pneumoniæ	...	200 millions	
Streptococcus pyogenes	...	80 millions	

Two doses of $\frac{1}{2}$ and 1 c.c. respectively were to be given at ten days' interval. This vaccine was used with considerable success in the army, and was also employed in the case of troops carried in transports.[1]

Without the co-operation of the people it is impossible to cope with an epidemic, which is sudden in its onset and spreads quickly over a wide area. It is, therefore, necessary to organize associations, the members of which should volunteer to assist in the distribution of medicines, milk, and proper clothing to the poor patients, and also the food to afflicted families.

Lastly it is very essential to educate the people regarding the mode of infection and prevention of the disease by means of leaflets, posters, notices in the press, lectures in the schools and colleges and exhibition of magic lantern slides or cinema films.

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1. Official History of the War, Med. Services, Hygiene of the War, Vol. I., p. 339.

CHAPTER XXIII.

VENEREAL DISEASES.

THESE are the so-called social diseases, affecting all classes of society and distributed all over the world. In addition to causing untold misery and disaster they lower the vitality and diminish the physical progress and efficiency of communities.

The Venereal Disease Act, which was passed in the United Kingdom in 1917, defines venereal diseases as syphilis, gonorrhœa and soft chancre.

Syphilis.—This is a specific infectious disease caused by the *Spirochæta* (*Spironema* or *Treponema*) *pallidum*, discovered by Siegel and Schaudin in 1905. It is a minute protozoan parasite, actively motile, and measuring from 4 to 20 microns in length and 0.25 micron in breadth. It is a spiral filament, showing usually eight to twelve very regular, short, sharp curves, and tapering to a fine point at the extremities owing to the presence of a very delicate flagellum at each end. Another protozoan parasite, *Spirochæta refringens*, is frequently found associated with *S. pallidum* in genital ulcers, but it is larger, thicker, has blunter ends, and has fewer less regular and open curves. It is admitted to be saprophytic in nature.

S. pallidum is found in the scrapings from the primary chancre (sore). In the second stage of the disease it is found in the indurated lymphatic glands, skin lesions, mucous patches, blood, cerebro-spinal fluid and also in the spleen, liver and other organs. In the third stage it has sometimes been found in very small numbers in gummatta, but in the majority of cases it cannot be found in these lesions, which are consequently considered to be non-infective. In congenital syphilis the parasite is found in large numbers in almost every organ and tissue.

Modes of Infection.—In a large majority of cases syphilis is transmitted by sexual intercourse. The cork-screw-like spirochætes enter through an abraded skin or mucous membrane, though they are probably able to penetrate the unbroken skin or mucous membrane. In a few cases the disease is conveyed by means other than sexual intercourse, when the primary lesion is known as an extragenital chancre, and may be found on any part of the body. Thus the disease may be conveyed directly by kissing or indirectly by an infected drinking cup, smoking pipe, towel, handkerchief, shaving brush, razor, etc. Medical men and dentists may contract the disease from handling syphilitic patients, and midwives and wet nurses are apt to acquire the disease from infected infants. Infected nurses may also communicate the disease to babies nursed by them.

In congenital syphilis the virus is transmitted from parent to offspring, even "unto the third and fourth generations". The syphilitic husband infects his wife, who in turn infects the embryo. The spirochætes, which are in the circulating blood of the mother enter the blood of the fœtus through the placental circulation. If infection occurs in the early months of pregnancy, abortion is the usual result. If it occurs in the later months of pregnancy, the fœtus may grow to full-term, but is still-born or born alive with syphilitic manifestations on the body. In some cases the infant may be born apparently healthy, but may show syphilitic symptoms after a lapse of weeks, months or possibly years.

The incubation period of syphilis varies from two to eight weeks after inoculation, the average period being twenty-five days. The secondary period of incubation *i.e.*, the period between the appearance of the primary chancre and the manifestation of the first constitutional symptoms is, on an average, six weeks, though it varies from four to eight weeks.

Gonorrhoea.—This is one of the most wide-spread and serious of infectious diseases, and is caused by the *Gonococcus* or *Diplococcus gonorrhœæ*, described by Neisser in 1879. This

organism occurs in the purulent discharge of gonorrhœal infection of the genito-urinary passages and the conjuctivæ. It is found in the polymorphonuclear leucocytes as a diplococcus consisting of two kidney- or bean-shaped cocci, lying in pairs with their flat or concave borders facing each other. The organism is ærobic, gram-negative and non-motile. It grows at 37° C. Being very delicate it is rapidly destroyed outside the body by weak germicides, drying or exposure to the air. It is killed in a few minutes at 56° C.

In man gonorrhœa causes a large amount of ill-health and disability on account of prostatitis, vesiculitis, epididymitis, stricture of the urethra and arthritis. In females it generally causes the inflammation of the pelvic organs and consequently sterility. In newly born infants it causes ophthalmia neonatorum, which causes probably more than twenty-five per cent. of the total blindness in the community. The conjuctivæ of the child are infected by the gonococcus, when the head is passing through the infected passages of the mother during delivery.

Modes of Infection.—The disease is usually conveyed by sexual intercourse, but may, sometimes, be conveyed to children through infected linen, towels, etc. The eyes may be directly infected by contaminated fingers. The disease is not contracted by urinating at a place used by a gonorrhœal patient, by eating hot and spicy food or by some other way evolved by popular imagination and superstition.

The incubation period of gonorrhœa varies usually from two to eight days, although according to Wolbarst it may be as short as 24 hours and as long as 2 weeks.

Soft Chancre.—This is also known as a chancroid. It is a local, auto-inoculable, non-syphilitic ulcer, occurring usually on the penis or vulva as a result of impure sexual connection.

The soft chancre is caused by a specific bacillus, described by Ducrey in 1889. It is an extremely slender, rod-like strepto-bacillus, which does not form spores or stain by Gram's method.

The soft chancre does not produce systemic infection or produce any serious complications. But it is liable to become phagedæmic owing to mixed infection.

Immunity.—There is no natural immunity against venereal diseases. One attack of syphilis does not confer immunity against subsequent attacks, but re-infection is almost impossible during the course of the disease. One attack of gonorrhœa also does not afford protection to the patient from subsequent attacks.

Preventive Measures.—The Public Health authorities of several countries in Europe and America have recently adopted measures to reduce the incidence of the venereal diseases. On the publication of the report of the Royal Commission on Venereal Diseases in 1916, a vigorous campaign was started in the United Kingdom against the spread of these diseases and, as a result of this, the Society for the Prevention of Venereal Diseases and the National Council for combating Venereal Diseases came into existence. In 1920-21 the latter council with the sanction of the Colonial Office, the Foreign Office and the Treasury, despatched educational commissions to certain of the Crown Colonies and Protectorates with a view to confer with the Colonial Government authorities as to the steps—both preventive and curative—that can be taken to reduce the incidence of venereal diseases, and to discuss with the local authorities the preparation of constructive proposals with reference to the possibilities of developing a complete scheme for the prevention and treatment in each colony.

In spite of all these efforts India has made no progress in this direction. The venereal diseases are very common in this country, especially in large cities. More than 30 per cent. of the population are infected with these diseases, and no measures for their control and prevention have been taken either by the State or Public. It is very essential to educate the public opinion and to awaken the public conscience so that appropriate steps be taken to combat these social maladies,

which are truly regarded as the most formidable enemies of the community.

The measures for the control and eradication of the venereal diseases may be considered under the following heads :—

1. Education.
2. Personal Prophylaxis.
3. Treatment.
4. Notification.
5. Restriction of Prostitution.

1. **Education**.—The first essential step in the education of the public is to impress upon them that "the principal cause of the venereal diseases is promiscuous sexual intercourse". It is also necessary to inform the public of the nature and dangers of these diseases and the methods of avoiding and preventing them. This can be effected by issuing pamphlets and small books in local vernaculars and distributing them free, and by cinema films and lantern lectures to the public at temples, fairs, maternity centres, factories, mills and other public places, where the people can be collected. Medical men can help a good deal in this matter.

Instruction in the physiology and hygiene of sex should be made compulsory in the higher classes of secondary schools of both boys and girls. This should form a series of short lectures in the form of personal talks regarding the formation of character, self-control, chastity and continence, so that it might help the grown up students in curing or preventing the contraction of undesirable habits, and in avoiding the temptations and dangers, which they will encounter on entering the world after leaving their schools. This teaching should also be supplemented by the parents and guardians by talks on sex to their sons and daughters after they have attained the age of puberty.

Young people should be afforded ample facilities for healthy and vigorous exercises, so that with a healthy body and mind they would be more fitted to control their carnal

passions. They should also avoid stimulating food, intoxicating drugs and indecent literature.

2. **Personal Prophylaxis.**—This consists in self-disinfection (*a*) immediately before or (*b*) directly after coitus.

(a) **Immediately before Coitus.**—The genitalia should be anointed with an ointment containing 33 per cent. of calomel. Owing to the oily covering there is a minimum amount of friction, hence there is a very little chance of abrasions occurring during coitus. The ointment also acts as a coating, which prevents the entrance of the venereal disease germs. A condon or sheath made of india-rubber or membranous tissue might be worn by the male as an additional safe-guard.

(b) **After Coitus.**—The germs of the venereal diseases are easily killed by a disinfectant, and remain on the surface of the parts for an hour or two after an exposure to infection before they enter the system. Hence these diseases can be prevented if a disinfectant is applied to the parts within this period after exposure to the risk. The method of disinfection is described below :—

The genitalia should be thoroughly washed with plenty of soap and water, and with a 1 in 1,000 solution of potassium permanganate, the foreskin in non-circumcised cases being turned back and thoroughly cleansed. They should then be rubbed for at least ten minutes with half a teaspoonful of ointment containing 3 parts of calomel, 4 parts of hydrous lanolin and 2 parts of white vaselin. While rubbing the ointment special attention should be paid to the glans penis, corona glandis, prepuce and the anterior portion of the scrotum. The calomel ointment acts almost as a preventive against syphilis in man, if efficiently used in time. As a preventive against gonorrhœa the urethra should be irrigated with the solution of potassium permanganate or a 2% solution of protargol or a 10% solution of argyrol.

In cases of women the sexual organs should be thoroughly douched with the potassium permanganate solution and then

rubbed with the calomel ointment. But owing to the inaccessibility and complicate nature of the female genital parts it is very difficult to ensure their thorough disinfection.

This prophylactic method has been used with success in armies and navies. Sir G. Archibald Reid[1] mentions a case of the first battalion of the Yorkshire Regiment stationed before the last Great War at Dehli, a very hot-bed of venereal diseases. The men were supplied with pill-boxes containing crystals of potassium permanganate, and were advised to make a solution and disinfect their genitals immediately after incurring danger. During the four years that the battalion stayed at Dehli it had only six cases of venereal diseases instead of many hundreds. At Mhow venereal diseases were reduced by similar means to negligible proportions.

In certain cities in Europe and America facilities have been provided to the civil population in public conveniences, at police stations, or at other suitable places known as ablution centers, where disinfection soon after exposure to risk is carried out by specially trained attendants at any time of day and night.

This method of self-disinfection is strongly advocated by the Society for the Prevention of Venereal Diseases, who have issued the following instructions for men[2] :—

A. Materials required.—

(*a*) Some cotton wool.

(*b*) A small bottle containing a disinfecting solution.

(*c*) Some 33% calomel ointment.

B. Methods of Application.—

I. *If exposure to risk takes place out of doors or where complete disinfection is impracticable.*

(1) Make water.

1. Journal of State Medicine, Vol. XXIX, Jan. 1921, p. 2.

2. Venereal Disease, Its Prevention, Symptom and Treatment by H. W. Bayly, Ed. II., 1924, pp. 3-13.

(2) Soak a swab of cotton wool with the disinfecting solution. Draw back the fore-skin, carefully swab the head of the penis, especially at the opening of the pipe, and the whole of the under surface of the fore-skin.

These steps must be taken within an hour of exposure to risk.

Note.—The careful swabbing of the penis with the disinfectant is the *most important* measure.

(3) On returning home the sexual organs must be thoroughly washed with soap and water and 33 % calomel ointment well rubbed into the penis drawing back the fore-skin as in (2) above.

This must be done within six hours of exposure to risk.

II. *If exposure to risk has taken place indoors a more complete immediate disinfection should be made.*

(1) Make water.
(2) Wash the sexual organs with soap and water.
(3) Swab with the disinfectant solution as in "I".
(4) Rub calomel ointment well into the penis.

Note.—It is an additional safeguard to apply calomel ointment before intercourse.

III. *If exposure to risk has occurred while under the influence of alcohol so that the precautions recommended in "I" and "II" have not been promptly taken, the chance of infection* may be considerably lessened, though it cannot be removed, by taking as soon as possible all the steps mentioned in "II", well rubbing the ointment in for ten minutes, and in addition syringing the pipe with disinfectant solution of half the strength recommended for swabbing the outside; *i.e.*, add an equal quantity of water to the solution and squirt about a tea spoonful up the pipe with a glass syringe. Do this three times, then fill the pipe and hold the solution in for

three minutes by pinching the lips of the pipe. The method is not nearly as reliable as the immediate disinfection and is useless after 12 hours.

IV. If none of these precautions have been taken and there is reason to believe that infection is probable, a doctor should be consulted at the earliest possible opportunity.

Note.—The above mentioned methods of self-disinfection *are only useful for preventing the disease and are quite useless for cure or treatment* if the diseases have already started.

V. *Prescriptions for materials required.*—

(a) *Disinfecting solution.*—

(1) *Potassium permanganate.*—One five grain tablet or sufficient of the crystals piled up to cover a three penny piece (two-anna piece) dissolved in half a point of water.

(2) *Condy's fluid.*—One teaspoonful to half a pint of water.

Note.—4 tablespoonfuls (2 ounces) of either of these solutions carried in a small bottle will be enough for one application.

(b) *Calomel Ointment (Special Strength).*—Calomel 3 parts, lanoline (hydrous) 4 parts, white vaselin 2 parts. Half a small teaspoonful will be plenty for one application.

At the suggestion of Dr. Bayly, Hon. Secretary of the Society for the Prevention of Venereal Diseases the Holborn Surgical Instruments Company have put up in the market a pocket case for "immediate disinfection" containing tubes of calomel ointment, potassium permanganate tablets and a conical nosed syringe.

The self-disinfection as a prophylactic measure is objected to by many social reformers on the ground that it encourages immorality and tends to weaken self-control. The fallacy of this argument is effectively exposed by A. Mearns

Fraser, Medical Officer of Health and Port Sanitary Officer for the Borough of Portsmouth, in the January issue of the Journal of State Medicine for 1921, as quoted below :—

"So far as I have been able to understand it the charge of encouraging immorality rests upon two arguments, one, that by removing the fear of disease we are eliminating a deterrent to promiscuous sexual intercourse, and the other, that the carrying by an individual of a substance which will protect him from venereal disease acts as a powerful "suggestion" towards acts of immorality.

"In the first place I do not think it can be maintained that the fear of contracting venereal disease plays any material part in preventing men from indulging in sexual intercourse. Its most probable effect is to cause men to avoid professional prostitutes and to go instead with women whom they think will be free from disease (evidence shows that 60 per cent. of cases of venereal disease are contracted from "amateurs" and not from professionals). The great prevalence of venereal disease is in itself evidence that the fear of it is not a deterrent, for instance, the Royal Commission on Venereal Diseases recorded its considered opinion that not less than 10 per cent. of the population of large cities had been infected with syphilis, and syphilis is not nearly so prevalent as the other venereal disease, gonorrhœa. It is surely nonsense then in the face of such evidence to maintain that the fear of venereal disease has exercised any appreciable part in the prevention of promiscuous sexual intercourse.

"In the second place, the accusation that by instructing a man how to guard against venereal diseases we are inducing him to become immoral, appears to me to be based upon a false conception of morality. True morality is of a man's inner conscience, his ideals ; it is with him a matter of conviction, and no moral man will be induced to commit immoral acts simply because he becomes possessed with the knowledge that such acts can be committed without fear of contracting disease. The only ground on which the charge of inducing immorality can be with any appearance of truth be brought is on the hypothesis—and it is only hypothesis—that there are men desirous of committing immoral acts, but who are deterred from doing so for fear of disease. Such men, however, are already immoral at heart, and no great moral distinction can be drawn between a man who desires to commit an immoral act, but is deterred from doing so by the fear of disease, and the man who is not so deterred. Let me quote a passage from the Sermon on the Mount. Christ said : "Ye have heard that it was said by them of old time, Thou shalt not commit adultery ; but I say unto you, that whosoever looketh on a woman to lust after her hath committed adultery with her already in his heart." Our Lord placed in the same category both the man who only

desired to commit adultery and the man who actually did so. I venture to say, therefore, that even supposing some men, having acquired a knowledge of how to avoid disease, should proceed to commit acts of immorality which they have previously refrained from owing to a fear of disease, yet the moral standard of these men has not been lowered.

"And further, the argument that if a man is told that venereal diseases can be prevented by the use of potassium permanganate, he will carry this with him and it will act as a constant suggestion to immorality is equally untenable. I admit that if the policy of indiscriminately issuing ready made-up packets of disinfectants were adopted, there might be some grounds for objection; we however, propose nothing of the sort. We only suggest that advice should be given as to the steps to be taken to avoid venereal disease after exposure to infection, and if a man straightway provides himself with the means of protection, it is evident that he is already a man of immoral tendency, for he would not take the trouble to provide himself with the disinfectant unless he had the intention of indulging in illicit intercourse. Any suggestion to immorality that may occur is due to the man himself and cannot be blamed on the advice given."

3. **Treatment.**—It has been pointed out that the venereal diseases are mainly spread through the individuals suffering from these diseases. Hence it is quite obvious that the diseases will disappear, if all the infected individuals are rendered free from infection so that they are incapable of transmitting the diseases to healthy individuals. For this purpose there should be provision of ample facilities for early diagnosis and prompt and free treatment of cases suffering from the venereal diseases.

Many physicians have very limited knowledge of venereal diseases at present for want of proper attention being bestowed upon them in medical schools and colleges. Hence it is urged that a prominent place be given to the study of this subject in the final year course. The students ought to be familiar with the bacteriological and biological tests for the diagnosis and with the proper technique for the treatment of these diseases.

In salvarsan and its substitutes we possess a potent remedy for syphilis. Salvarsan administered intravenously promptly kills all the spirochætes except those which are

hidden in the cells of the inner organs. These must be destroyed by continuous administration of the drug, or by special methods. The most successful method of treatment is an alternate use of salvarsan and mercury. For syphilitic lesions of the central nervous system Swift and Ellis suggest the use of "auto-salvarsanized serum", *i.e.*, the serum of the patient himself, an hour after salvarsan is given. This serum is heated for half an hour to make the salvarsan in it more active, then diluted and injected into the spinal cord. Owing to the modern methods of diagnosing syphilitic infection it has been possible to lay down a definite standard of cure, which is as follows :—

Several negative Wassermann reactions and absence of any clinical symptoms during a year without undergoing treatment.

There is no special remedy which will speedily cure gonorrhœa, but it is an admitted fact that the present improved methods of treatment with vaccines have effected a large reduction in the number of chronic cases which are the main source of spreading the infection. It is difficult to lay down a definite standard of cure for gonorrhœa, but the Public Health Service of the United States of Amercia suggest the following rules [1] :—

Males : (1) Freedom from discharge. (2) Clear urine ; no shreds. (3) The pus expressed from the urethra by prostatic massage must be negative for gonococci on four successive examinations at intervals of one week. (4) After dilatation of the urethra by passage of a full-sized sound, the resulting inflammatory discharge must be negative for gonococci.

Females : (1) No urethral or vaginal discharge. (2) Two successive negative examinations for gonococci of secretions of the urethra, vagina, and the cervix, with an interval of 48 hours and repeated on 4 successive weeks.

In 1916 the Royal Commission on Venereal Diseases advocated facilities for prompt and reliable diagnosis and

1. Rosenau, Preventive Medicine & Hygiene, Ed. IV., p. 68.

treatment of venereal diseases and recommended that doctors should be given powers to detain patients suffering from venereal diseases in poor law institutions if necessary and that infected persons should not be allowed to contract marriage; such marriages if contracted should be declared null aud void. These were largely embodied into the Public Health (Venereal Diseases) Regulations issued in 1916 by the Local Government Board of England which passed the Venereal Diseases Act in 1917. In accordance with these regulations every County Council and County Borough Council in England and Wales and the Common Council of the City of London must prepare and submit to the Medical Officer of Health a scheme, (*a*) for the treatment at and in hospitals or other institutions of persons suffering from venereal disease; and (*b*) for supplying medical practitioners with salvarsan or its substitutes for the treatment and prevention of venereal disease.

In accordance with these regulations a large number of venereal diseases Clinics have been established in England, where patients are treated gratuitously and at the same time perfect secrecy is observed about them. But so far nothing has been done in India.

4. **Notification.**—Venereal diseases should be included in the list of notifiable diseases, so that the persons infected with these diseases should be forced to undergo treatment either by private doctors or in some institution or clinic. They should report themselves to the Medical Officer of Health every three months till they are pronounced to be non-infectious. The spread of infection by such persons should be treated as a crime punishable by a term of imprisonment or fine. These persons should also be prohibited during the infective stage from following occupations connected with the preparation, serving and selling of food products.

Schemes of compulsory notification have already been introduced into certain British Colonies and some provinces of the United States of America with a marked success in many cases, bus it is not possible to introduce it into this

country, especially when the people have false notions of modesty and sexual connection, and when there is no law to prevent the treatment of venereal diseases by quacks and charlatans. According to sub-section (2) of section 2 of the Venereal Diseases Act passed in 1917 in England it is considered an offence for any unqualified person to treat or offer to treat venereal cases or to advertise any medicaments for the prevention, cure or relief of any venereal disease except with the sanction of the Ministry of Health or local health authority.

5. **Restriction of Prostitution.**—Measures adopted for the prevention of venereal diseases are of no avail if no action is taken for the control of prostitution, which is the primary source of infection. It is futile to attempt to abolish prostitution altogether. Medical inspection of prostitutes which was in force in the cantonments of this country, and which is still in force on the Continent and in Japan has not proved successful in reducing the incidence of these diseases. On the contrary it has encouraged clandestine prostitution to a great extent. It is certainly objectionable to allow prostitutes to ply their trade openly in the main streets of our cities, where many innocent persons fall a prey to their solicitations and thus expose them to the risk of infection. It is, therefore, very necessary that the prostitutes must be segregated to a far distant and lonely place so that access to them may be very difficult. Certain municipalities in North India have segregated all the prostitutes in one place by passing special bye-laws. But in addition if they made arrangement for their medical inspection and systematic treatment of all infected prostitutes, the spread of infection from this source would be reduced to a very great extent. In European cities, especially Germany the incidence of these diseases is very much reduced owing to the municipal supervision of restricted "red light" districts and continuous medical attendance and enforcement of strict sanitary measures.

Fig. 69—An Insanitary Village

A, a group of ill-ventilated huts; B, a shallow *katcha* well; C, fields; D, cattle grazing near a tank, E, graveyards. F, a drain falling into a tank, G, a *katcha* tank.

CHAPTER XXIV.

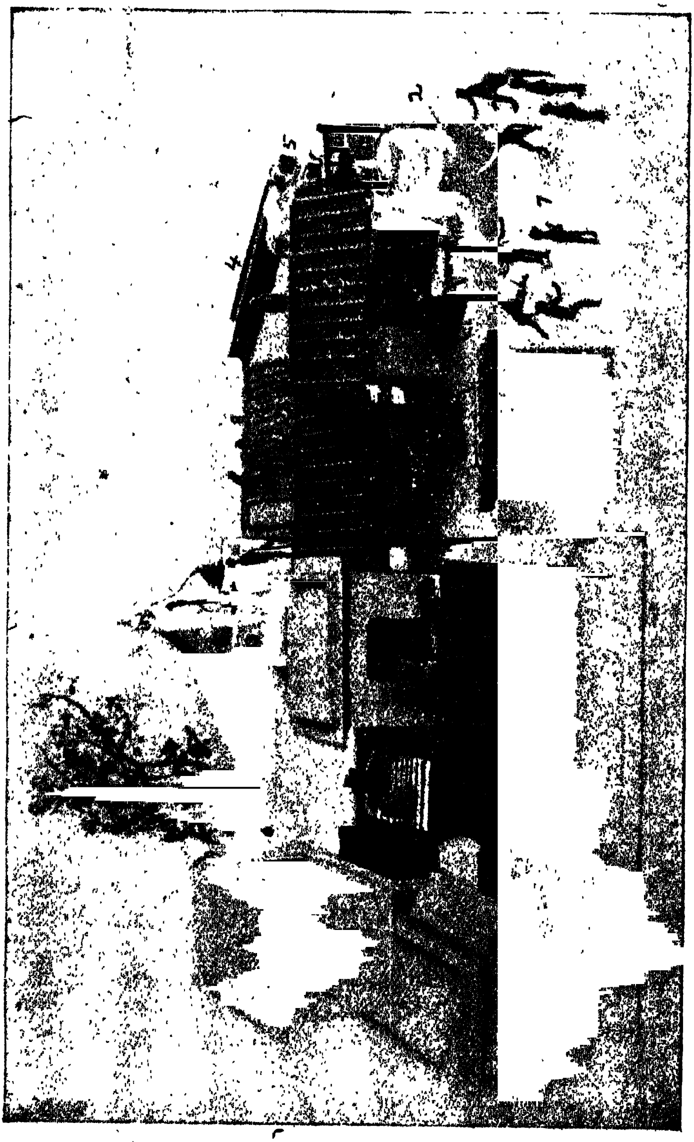
VILLAGE SANITATION.

IN India villages are in an insanitary condition owing to the ignorance of the people about the elementary principles of hygiene. It should, therefore, be a part of the duties of a sub-assistant surgeon in charge of a travelling dispensary to collect the people of a village at some prominent place, and to explain to them the advantages of general cleanliness and sanitation and the methods by means of which this may be observed. However, it should not be forgotten at the same time that the people must be willing to adopt those principles; otherwise no amount of sanitary rules and regulations enacted to guide them will be of any avail. For this purpose the best thing will be to introduce elementary education, and to include lessons on practical hygiene into vernacular text-books. In 1892 an Act known as the United Provinces Village Sanitation Act was passed, which empowers the Collector and the Director of Public Health (deputy) to take necessary steps to maintain the purity of water-supply and to adopt special preventive measures on a serious epidemic outbreak of some infectious disease in (Act XX of 1856) towns and villages containing not less than 2,000 inhabitants.

The main principles of sanitation are given below, which can safely be applied to these towns and villages.

HOUSES.

In villages no particular care is taken in selecting the sites for building houses. As a rule these houses are *katcha* ones made with mud taken from an adjoining dried pond or tank. They have no arrangement for ventilation excepting one main opening, which serves the purpose of an entrance and of exit as well. Owing to want of sunlight and fresh air in such houses, tuberculosis has been increasing in villages,



even though most people lead an outdoor life in agricultural occupations.

Cattle and fowls are kept either in front of the dwelling houses, or in the courtyards attached to them. Cowdung is allowed to be accumulated in front of the house, before it is taken to the fields for manure purposes.

In order to improve the sanitary conditions of the dwelling houses in villages, the following points should be carefully noted :—

1. Main streets or roads in a village should not be less than 30 feet in width, and the back lanes not less than 15 feet wide, if the houses are *pucca* ones ; but the roadway between the mud houses (huts) should be 20 feet wide, and the houses should not be more than 16 feet high. The width of the streets should be increased to at least 50 feet, if the houses abutting on the road are built of two storeys.

2. Houses should not be grouped together at random so as to obstruct ventilation, but they should be built in parallel rows with a courtyard in front as well as on the back, and there should always be a space of about 6 feet between houses or twelve feet between blocks of houses. These houses should be built on a raised plinth at least one foot above the general ground level. The foundations should consist of rammed *kankar*, or if the soil is good the walls may be built up from the bottom of the trenches. Burnt bricks should be used in constructing the walls upto the level of the plinth, and cheap material usually used by the people should be allowed for the walls above the plinth as also for the roofs.

3. There should always be two different sets of apartments, one of which should be devoted exclusively to domestic use ; and the other should be reserved for keeping cattle, fowls and other domestic animals. Each living room should have a window, equal to at least one-twelfth of the floor area opening directly to the outer air for admission of fresh air and sunlight, and an opening at least six inches square in an outer wall near the roof for the escape of foul and vitiated air. There should

be an open courtyard between these apartments, so that the passage of air and light might not be obstructed.

The apartments meant for the use of animals should be fully exposed to the rays of the sun, and the floor should be paved with stone or bricks-on-edge set in cement, so that no stinking should occur.

4. If possible, it is much better to induce people to make arrangements to keep their animals on their fields, or in some suitable place on the outskirts of a village, or in some less populous parts of the village. Care should be taken that these stables are not near any well or other public or private reservoir of drinking water.

5. Earth required for house building or for any other purposes should be taken only from tanks or hollows beyond the inhabited site specially set apart for this purpose, but no excavations should be made anywhere else within the inhabited area.

WATER-SUPPLY.

The chief sources of water-supply in villages are from wells, tanks, canals, rivers and streams.

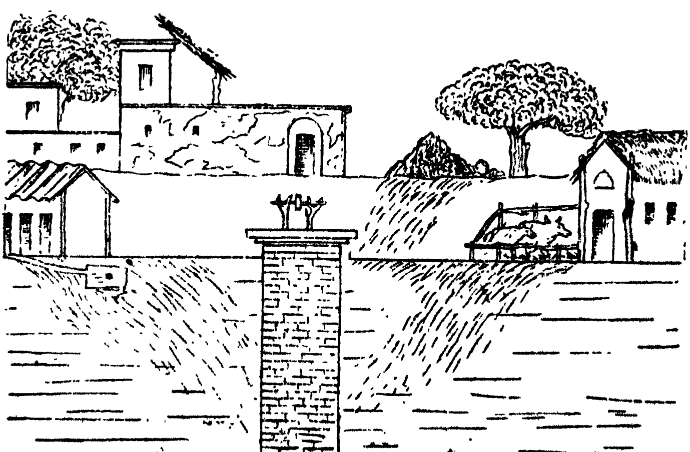


Fig. 71—Contamination of a well situated in the heart of a village.

Wells.—Wells are either sunk in the heart of the villages or on their outskirts.

A well drains the ground all round it in the shape of an inverted cone, the base of which is 4 times the depth of the well. If the depth of the well is 50 feet, it will

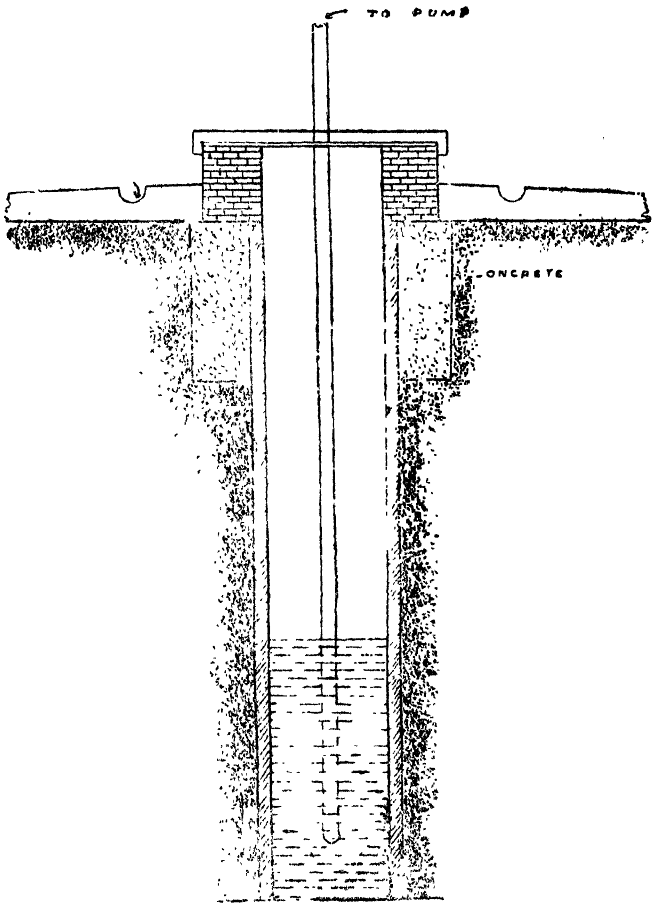


Fig. 72—Well, properly protected from surrounding contamination.

thus drain an area of 200 feet in diameter on the surface of the soil, that is to say, any impurity within this area will gradually drain into the well and affect its water. A well situated in the heart of a village, is naturally, therefore, always in danger of being contaminated owing to the proximity of latrines, cesspools, drains and cowsheds. To prevent such contaminations, superficial shallow wells should, as far as possible, be discarded, and deep wells should be used instead. These wells should, if possible, be on high ground and outside the village. The sides of the well should be steined by lining with brickwork covered thickly with cement or with stone slabs all the way from its mouth down to the level of the impermeable layer of the soil, which it pierces. The lining must be smooth, so as not to allow birds to build their nests in. The ground round the well should be paved with stone, and covered with concrete and should have a slope in the opposite direction from the well so that no waste water should soak and percolate into it. It should have a parapet round its edge and a plinth with gutters to carry off the waste water. The mouth of the well should be covered with trap-doors, so that no filth might drop into it. The well should also be provided with a windmill or pump, wherever possible. No trees should be allowed to grow near it, so that dead leaves and droppings of birds and squirrels might not fall into it. People should not be allowed to wash their soiled clothes and vessels on its platform, nor should any sick persons be given their sacred baths on it. There should be a separate iron bucket and chain or rope to draw water, and none should be allowed to use his own dirty *lota* or *ghara* or leather skin (*mashak*) and a rope, which may carry disease-germs to water, if any case of cholera or any other water-borne disease has occurred in the house of such a man.

The practice of throwing sugar, flowers, cocoanuts and sacred threads into a well should be put a stop to. A well should be cleaned at least every 6 months, when all the refuse, silt and stagnant mud, and all the foreign impurities at the

bottom, must be scrupulously scooped up and carried away. At the same time the lining of its walls should be repaired, if there are any defects, and offshoots or roots of any trees growing on the sides of its shaft should be removed. The troughs built for watering cattle by charitably disposed persons near a well, should always be kept in a clean condition, and

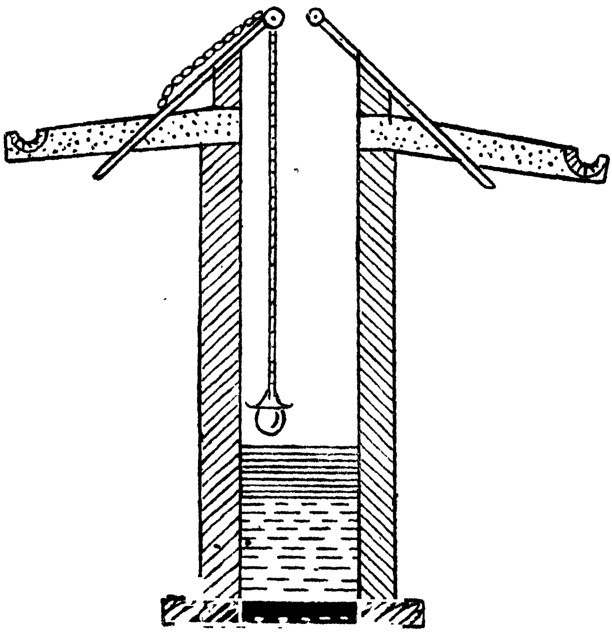


Fig. 73—The model of a Well as recommended in the "District Board Manual".

animals should never be allowed to be washed there. If any repairs are needed, they should be promptly carried out. Provision should also be made to repair *katcha* wells.

It will not be out of place to quote the following instructions from the District Board Manual for the protection of wells :—

The *pacca* brickwork (of the cylinder wall) should be so sloped off at the top that people drawing water from the well

cannot stand upon the top or place *gharas* there. This wall may be about 14 inches thick and 2½ feet high above the platform. Two or more pully blocks, according to requirements, should be fixed on this wall as shown on the plan and

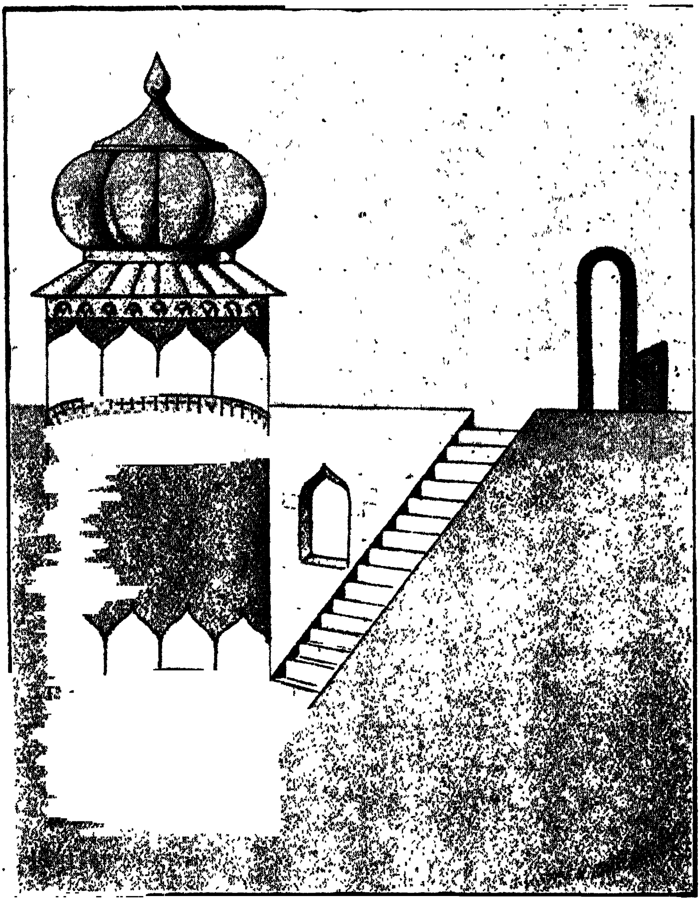


Fig. 74—A Step Well or "Bauri".

may be of either wood or iron. The object of the raised wall is to prevent the splashings from dirty or disease-infected

clothes or hands and feet from going into the well. The sloping top is to keep them from putting their feet or *gharas*, which may have come in contact with vomit, etc., of a cholera patient, on the coping of the edge of the well and thus greatly increasing the danger of infecting the water of the well. Where there is an already existing *pacca* platform the rammed *kankar* will not be required. In the event of a new platform being required, it should be made of rammed *kankar*, as shown on the plan, at least 8 feet broad. The platform should be well drained and the length of the *pacca* drain carrying off the water should be one-and-a-half times the depth of the well.

Step-Wells.—In some districts wells or "bauris" are provided with steps, so that the people have direct access to the water—an arrangement which is largely responsible for the dissemination of cholera, when it is prevalent in the neighbourhood, and for the spread of guinea-worm at all times. They are particularly dangerous, when they happen to be on a route much frequented by pilgrims. Such wells should, therefore, be discouraged and where possible should be converted into draw-wells by removing the steps.

Tanks.—Tank water is liable to be polluted in several ways. In the early morning people go for nature's call in the vicinity of a tank, and then perform ablutions in the tank itself. They rinse out their mouths, clean their throats and teeth and spit into the water. They take their baths, and wash dirty clothes and cooking utensils. Cattle are seen wading, drinking and fouling the water. In Bengal jute is steeped in tanks. In short, tank water is a fruitful source of danger to health, and should always be condemned. Wells should, therefore, be sunk at a distance of 10 to 20 yards from the tanks. However, if tank water is the only available source of drinking water for the community in a village, there should be at least two tanks—one to be reserved for drinking purposes and the other to be used strictly and solely for purposes of bathing and washing and watering animals. The

tank, which is to be used for drinking purposes, should be surrounded by barbed wire fencing to keep people and cattle from getting into the water, and the margins should be paved with stone, or grass should be grown on its banks. It should then be connected with draw-wells dug outside the fence, so that there should be very little danger of water pollution by people getting into the tank to fill their *gharas*.

Canals.—In those villages, where the water-supply is from canals or irrigation channels, the following steps should be taken to guard against their contamination :—

1. People should take water from the canal far above the village.
2. Ships and boats should not be allowed to frequent the canal.
3. There should be no house, hut or tree within 50 feet from the edge of the canal.
4. No fishing should be allowed in the canal from where water is taken for drinking purposes.
5. There should be no latrines within 200 feet of the canal, and its banks should not be used for purposes of nature.
6. Animals should not be allowed to graze in the vicinity, nor should they be watered there.
7. No one should wash his clothes or take a bath there.
8. A lower portion of the canal below the village should be used for washing and bathing purposes, and for watering animals.

Rivers and Streams.—In the case of rivers and streams, the banks must be kept clean and free of jungle, and the beds of old watercourses and of *nullahs* which flow into them must be kept clean and guarded from improper uses. The water should be taken from above the village, and no offensive trades, no burial grounds nor burning *ghats* should be allowed on or near the banks of the stream above the village. Cattle should not be allowed to graze or to be watered there, but a lower part of the river must be set aside for watering cattle and for washing and bathing purposes. Carts and carriages should

not be allowed to cross the river at a place from where the village community take their water-supply. A watchman should be appointed to guard against all these sources of pollution.

Moreover, with all these precautions, it is impossible to guard against the contamination of water in canals and rivers, for where the river or the canal supplies drinking water to several villages along its course, the villages lower down must necessarily use contaminated water coming from the portion of the river or canal set apart for inferior purposes in the villages higher up. In this way cholera is easily spread from village to village situated along the banks of a river or a canal, as is frequently observed. It is, therefore, best to provide properly constructed wells in such villages, so that the people may not resort to rivers or canals for their water-supply.

CONSERVANCY.

The sites of all ruined houses should be levelled, and vacant sites should be enclosed by owners, so that people cannot use them for purposes of nature. All useless jungle should be removed, and overgrown bushes and weeds growing within and around the village should be removed at least once every six months and buried under four feet of ground. The lower branches of all trees should be lopped off, and other trees (Eucalyptus or *Neem*) should be planted on bare, damp, vacant spaces, and between the village and any marshy ground. Trees should also be planted along both sides of the streets, but should be such as would give a maximum of shade with a minimum of obstruction to free circulation of air. Marshy grounds and unnecessary ponds should be drained or filled up. The roads and streets should be kept in a trim condition, and pits, hollows and depressions should be filled up, so that there should be no obstruction to the outflow of storm water. The streets in the village should be raised in the centre, with a slope to each side, leading to a drain which should be kept free and clean, and no refuse or rubbish should be allowed to

accumulate to obstruct the flow of water. Owing to want of adequate funds in villages, it is not possible to engage sweepers to clean and sweep the roads and streets, but the owners themselves should be held responsible to broom the road in front of their own houses, and thus to keep it clean and free of dust.

The people should be prevented from collecting on their premises house refuse, rubbish and cowdung for the purposes of manure, nor should they be allowed to throw it any where in the village, but should be asked to carry it once a day in closed baskets and to deposit it on some fixed places or depôts specially selected for this purpose on the outskirts of the village far away from any source of drinking water-supplies. Care should be taken to cover it well with dry earth, so as not to allow flies to collect or breed. It should then be apportioned off to several contributors when required by them as manure for their fields, or if this is not possible, it may be sold by auction by some responsible authority, such as a Naib-Tehsildar.

No one should be permitted to perform offices of nature in the village street, lane or open space. Some sites outside the village not near any well or drinking water-supply should be set apart for this purpose. These places should be divided into two separate parts, one for men and the other for women and children. They should be surrounded by a thick hedge, and cattle should be carefully kept out. In these places, trenches one foot broad and $1\frac{1}{2}$ feet deep and as long as required should be dug up. Each person using the trench should be instructed to cover up his filth with dry loose earth. To secure privacy these trenches may be partitioned into separate trench latrines by erecting grass screens (*tatties*). When one piece of ground has been so used up all over, another site should be selected, and the old site should be ploughed for growing crops.

Villagers in better circumstances, especially women, may object to go to the places thus marked off for the purposes of

nature. They may, therefore, be allowed to construct a private latrine in the corner of the backyard farthest away from the house. The latrine should be provided with a roof raised one foot above the walls to allow of free ventilation, and its floor should be raised at least six inches above the surface level of the court-yard. This latrine should be daily cleaned out by scavengers employed by the house owners.

Graveyards.—These should not be situated near the dwelling houses, but should be at a distance from a village well away from the sources of water-supply. A grave should be at least 6 feet deep, 2½ feet broad and should not be less than 2 feet distant from the nearest grave. The body should be interred within eight hours after its arrival at the burial ground, and should not be buried in any grave in which another body has already been interred. In order that the graves should not be disturbed for a period of seven years, an area of half an acre for the graveyard is desirable for a population of 1,000 Mahomedan inhabitants, if land is available, but may be reduced to quarter of an acre, where such is very expensive. There should be an enclosure wall to the graveyard to prevent jackals from frequenting it. The ground round about the graves should be grassed, and some trees should be planted to remove dampness and moisture from the soil. Corpses should never be allowed to be exhumed unless under exceptional circumstances, and that too, not without the written permission of the District Magistrate and the Superintendent of Police.

Burning Ghats.—The bodies of Hindus ought not to be burned on the banks of a river above its stream or near a tank which supplies drinking water to the village. They should be burnt only at properly fixed places, and always below the area from which the drinking water is taken. Owing to the high cost of fuel the bodies of poor Hindus are partially burnt, and the charred bodies are thrown into the river or stream, which may be contaminated by disease germs. It is, therefore, necessary that the rich proprietors of village lands should

financially help the poorer people of the village to burn the dead bodies completely, so that the burnt ashes alone might be thrown into the running stream. The bodies should be burnt within eight hours after their arrival at the burning *ghat*. There should also be proper arrangement for the disposal of unclaimed bodies. It is also necessary that no one should be allowed to remove wood or coal that had been employed in the pyre from the burning ground, and all such wood or coal should be reduced to ashes.

Offensive Trades.—Offensive trades, such as the skinning of animals, the curing of skins, the keeping of pigs, etc., should not be allowed to be carried out within the inhabited area, but separate localities outside or on the outskirts of the village should be assigned for such purposes. These places should not be in the windward direction of the village or within at least 100 feet of a source of drinking water. Hides, etc., should never be soaked in a tank or a running stream, whose water is used for drinking and domestic purposes.

PROTECTION OF FOOD SUPPLIES.

In bigger towns it is much better to have in their centres special markets for the sale of vegetables and other eatables, so that they may be easy of inspection by proper authorities.

Stale vegetables and unripe or over-ripe fruits should never be allowed to be sold. This is especially important during outbreaks of cholera. Sweets sold in confectioners' shops in the *bazaars* should be made of articles of proper and wholesome quality and should be properly cooked, otherwise they are liable to produce digestive disturbances. Persons preparing sweets should observe thorough cleanliness. They should wash their hands and feet before they touch any raw materials with which they are going to prepare several varieties of sweets. The floor of a shop must be clean and must be made *pacca* instead of it being made *katcha* and being *leeped* with cowdung, so that rats and mice may not frequent it. The

shop should not be used as a dwelling house by the owners, who must have a separate house for residence. The shop should be well ventilated and lighted, and there should be an arrangement for the escape of smoke, if there is no separate kitchen to prepare sweets. Trays used for exposing sweets for sale should be thoroughly cleaned, and should be tinned every now and then, if they are made of copper or brass. There should be an arrangement to protect them from flies by covering them with a wire-gauze netting or even a clean muslin cloth. It will be still better to keep sweets in wooden almirahs, the sides of which are fitted with wire netting instead of glass panes.

Care must also be taken that the *banias* do not sell unwholesome corn or unwholesome flour of wheat or any other variety, and that they construct their shops rat-proof. If they cannot afford to build *pacca* shops owing to the prohibitive cost, they can build the rat-free shops of any material, provided the roof is water-tight, by raising the floor on uprights surrounded by rat-guards similar in design to those commonly employed on ships. These uprights should be at least 3 feet high, and would support the beams on which the floor rests. This floor may be made of wood. The space underneath the floor should be left open, and should be kept free from weeds and the growth of rank vegetation.

EPIDEMIC DISEASES.

It is very necessary for the Assistant Director of Public Health to inspect towns and large villages of 5,000 inhabitants and upwards in all parts of his circle during his tours or journeys, so that he can report on their general sanitary defects. On the outbreak of an infectious disease he should visit the place and recommend to the Magistrate the necessary preventive measures to be adopted. The Magistrate should at once take steps to arrange for the employment of a proper conservancy agency to have lanes, open spaces and the village generally kept clean and free from rubbish and offensive matter, which

should be properly disposed of at a distance from the village or should be destroyed. He should also take steps to carry out the disinfection of the houses, huts, sheds, clothing, bedding or other articles, which are likely to retain or convey infection. The necessary arrangement of treatment of the patients with proper supplies of medicine should also be taken in hand at once.

During the epidemic outbreak of cholera in a village all the wells with the exception of one or two of the best should be closed temporarily with boards and sods. The wells left open should be disinfected with potassium permanganate, and *kahars* should be specially appointed to draw water from them. No other person of the village should be permitted to draw water from them. The *kahars* should be furnished with a new rope or one that has been well soaked in potassium permanganate solution. At each end of the rope should be affixed an iron bucket or a kerosene oil tin, which should never be removed from the well during the outbreak. The *kahars* should supply water by pouring it into a hollow bamboo or tin *purnalla*, below one end of which is presented the water vessel which requires filling The *kahars* should continue to work on the wells for six days after the occurrence of the last cholera case.

REGISTRATION OF BIRTHS AND DEATHS.

The report of births and deaths in towns and villages administered under Act XX of 1856 is made by the *chaukidars* at the police station within their circle, where the head constable writer, who is known as the circle registration officer, makes entries in separate registers of births and deaths. Still-births are also recorded separately. The *chaukidars* usually make these reports once every week, when they visit the police station. This arrangement does not seem to be satisfactory, inasmuch as the *chaukidars*, being illiterate, have to depend on their memory for the dates of the occurrence of the births and deaths during the interval that they do not

visit the police station, though they are permitted to have these entries entered up in their pocket register by the *patwari*, or any other village official. Hence it is necessary to entrust this work to *mukhias* (village head men), *patwaris*, or school masters in those towns where there are schools, and to medical men in those towns where there are dispensaries. These statistics are at present verified by the circle inspector and the officer in charge of the police station, but it is better that they should be verified by the sub-assistant surgeons in charge of the travelling dispensaries. It is also necessary that these should be tested at least once a year by the District officer and his staff when on tour. Members of district boards should interest themselves in testing the accuracy of the vital statistics in rural areas.[1]

Besides, the causes of deaths as entered in a death register are not reliable owing to the fact that more than half the people in India die without being seen by a qualified medical man, and the so-called registrars are too ignorant to label the disease from symptoms. To ensure, therefore, correct recording of the causes of deaths as far as possible, the Deputy Directors of Public Health, who have to test birth and death registration, should draw up for the guidance of these men a set of certain questions leading to the symptoms of different diseases to be put to the relatives of a deceased person.

Whenever deaths are found to be more than usual in any village or town, care must be taken to find out a cause or causes operating to enhance the number of such deaths, and necessary precautions should at once be taken to check it, if it happens to be an infectious epidemic disease.

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1. *Vide* U. P. G. O. No. 845—IX-106, dated the 5th July 1898 ; The District Board Manual, 1906, p. 302.

CHAPTER XXV.

FAIRS, FAMINE CAMPS AND POOR HOUSES.

FAIRS.

AT Hardwar, Allahabad, Benares, Ajmere, Pandharpur and other sacred places of pilgrimage, fairs have been held annually for a very long time, where hundreds of thousands of people congregate together for purposes of worship. In ancient times, these fairs were more or less commercial institutions, where people from different districts used to barter their goods locally manufactured. Even now fairs are held at Meerut, Batesar, and other places, where horses and cattle are sold, as well as other articles of merchandise.

Owing to improved facilities of travel the number of pilgrims going to these large centres of pilgrimage has increased considerably, and the risk of importation and exportation of disease to and from these centres has consequently become greatly intensified, and as such, they form an ever-increasing menace to public health. It is, therefore, necessary to make the following medical and sanitary arrangements for the pilgrims at such places.

Duties of the Magistrate.—The Magistrate[1] of the district, in which the fair is held, is the officer in charge of the fair. With him must rest the responsibility for the general management, for the measures adopted for the protection of life and property and for the enforcement of the sanitary regulations. In case the Magistrate is unable to take immediate charge of the fair, he should depute one of his covenanted staff for the duty. He should communicate freely and confidentially with the Director of Public Health on matters relating to the sanitation of the fair and to the health

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1. *Vide* Manual of U. P. Government Orders, paragraphs 2049 to 2077.

of the people attending it, and should endeavour, by the utmost weight of his authority, to enforce the observance by the people assembled of measures deemed essential to their protection from disease. The Director of Public Health exercises administrative medical and sanitary control over all fairs and large gatherings, and additional medical officers placed at his disposal will be under his entire control during the time of the fair or gathering.

The Director of Public Health or an Assistant Director of Public Health should be in charge of the medical and sanitary arrangements at all large important fairs and the District Medical Officers of the smaller district fairs. In the absence of these officers the Civil Surgeon of a district is responsible for advising the Magistrate on any points of sanitation in connection with the fair to be held in the district.

About a month or two before the occurrence of a large fair, the Magistrate of the district should inform the Director of Public Health of the date of the fair and the probable number of persons likely to be present, with an estimate of the strength of the conservancy staff and the police, according to his opinion, required for conservancy and the enforcement of sanitary regulations. The Director of Public Health should reply if he agrees to the proposals, or should suggest modifications and at the same time inform the Magistrate of the date on which he or the Assistant Director of Public Health would be likely to be present at the fair. The Magistrate should then make necessary arrangements to collect the staff of vaccinators, sweepers, and police.

Ground Plan.—Some time before the fair the officer-in-charge should prepare a ground plan of the site of the fair correctly drawn to scale. Upon this plan the site should be divided by roads of communication 100 to 200 feet in width as may be most convenient for the purposes of the fair the area being separated into divisions, each possessing its own complement of *banias'* and sweetmeat sellers' shops, supervising and conservancy staff.

The land between main roads should be divided by cross-roads, and the space between any two cross-roads should be considered as a section of the fair. The enclosure for the tahsil and the police should be situated prominently on the main road. Tho frontages of both sides of the main roads are generally occupied by shops, which are usually erected on plinths, hence the depths of these frontages should be sufficient to allow for the excavations necessary to form these plinths. Blocks for the residence of pilgrims should be reserved behind the shops. A strip, 10 feet in width, should be left along the breadth on opposite sides of each block as a sanitary area for the erection of urinals, etc.

The site of the fair should then be laid out in correspondence with the plan, the main roads, if possible, being permanently marked out by stones placed in line on each side of the road. All jungle growth or high crops within a hundred yards of the edge of the fair should be cut down and removed, and, if suitable, may be used to construct latrine fences or to make roads. Shallow depressions should either be filled up or fenced. All pools, back-waters, etc., should be filled in or fenced by barbed wire or thorns if easily procurable or by an ordinary rope especially when under a police patrol. Whenever at any fair a very great assembly of people may be expected, strong barricades should be erected across the roads of communication at such places as the police authorities may determine.

The auction of sites for the erection of shops and pilrgim shelters and the location of *akharas* must be carried out as soon as the area is demarcated.

The people, as they arrive; must be made to encamp in orderly arrangement on the vacant spaces between roadways. No one should be allowed to encamp on a roadway. Shops of *banias* and sweetmeat sellers should be established in every division in sufficient numbers to furnish a supply of food for the division. These shops should be located immediately at the side of the main road, but not on the road.

Conservancy Arrangements.—The employment of an adequate staff of sweepers is the most essential. The local supply of sweepers should, where necessary, be supplemented by sweepers from outside, preferably professional sweepers from a municipality in the neighbourhood. If possible, sweepers should be furnished with quarters near their work. They should all be numbered and provided with badges. They should be divided into gangs, each gang being placed under the charge of a mate. Female sweepers should be placed in charge of latrines for females. All the sweepers should be under the direct control of the medical officer in charge, who would also be responsible for their inspection and payment. The medical officer would allot to each supervisor of a section of the fair—a sanitary Inspector, a Sub-assistant Surgeon or a Vaccinator as the case may be—the number of gangs for the efficient working of each sub-section. It is very necessary to keep in reserve gangs of peripatetic sweepers ready for emergencies. At fairs which last only a day or two the employment of such gangs on yellow flag areas will save the expense of erecting extensive latrines.

The selection of the sites of latrines should be made by, and construction carried out under the supervision of, an expert. The latrines should never be placed more than 100 yards from the edge of the fair. It is better if they are placed much closer, but they should never be placed in the midst of natural cover.

Where the fair is not too big or can be spread out in long lines all the latrines should be arranged behind the inhabited blocks on the edge of the fair. Where the inhabited area is crowded and compact, in addition to latrines on the outskirts, latrines should be provided behind each block or pair of blocks. While there is no danger in having latrines in the middle of a fair, provided always that they are of suitable design and properly tended, latrines so situated are disliked by pilgrims and should be avoided where possible.

For a fair that is visited daily by pilgrims who do not live within the fair area the number of latrine seats required may be put roughly at one for every thousand of the population; for those living within the fair area one for every three hundred. The type of latrines to be constructed is dependent on the nature of the soil on which the fair is held. The chief types of latrines used in fairs are—

1. The trench system on solid soil.
2. The trench system on sand or light soil.
3. The removable system with pans.
4. The yellow flag areas (for persons who refuse to use latrines) having no special arrangements except sweeper gangs.

1. **The Trench System on Solid Soil.**—Trench latrines are preferable wherever possible, as the essential feature of this type is that the excreta are deposited directly into the trench and buried *in situ*. This reduces to a large extent the work to be done by sweepers and makes it possible to keep the latrines clean in the largest fair. There should be a separate provision for latrines of males and females.

The latrines for males should consist of trenches 48 feet long, 10 inches wide, 18 inches deep and 7 feet apart, screened off in front and behind by moveable screens 6 feet high. The earth removed from the trenches should be banked up behind leaving a strip of 6 inches clear along the border for the feet at the time of using the latrine. The latrine should be divided into separate compartments by placing screens three feet wide and at intervals of three feet across the trench and into two sections by a screen four feet high placed in the centre, eight seats being arranged in each section. The front and rear screens should be placed so far from the trenches as to leave a path on one side sufficiently wide for the persons using the trench to pass without brushing against the screen and a narrow path behind the banked earth for the sweeper to pass along and fill in the banked earth over the excreta.

When the first trench is filled the screen in front of it should be removed and placed behind the second trench. In this way the screen which was originally behind the first trench would now become the screen in front of the second trench, and so on for as many trenches as would be required.

In the case of latrines for females the trenches should have the same dimensions, but should be only four feet apart without any separate compartments. When the trenches are filled, the matting screens surrounding the enclosure should be removed further back to enclose a second set of trenches and so on as required.

2. **Trench System on Sand or Light Soil.**—On sandy soil the edges of the trenches are apt to fall in of themselves or to break down with the weight of the user. Trenches in such soil should not be dug more than one day before they are required. Trenches may be dug 3 or 4 feet deep and 1½ to 2 feet broad in sand which will be covered in the rains and in which there are few nitrifying micro-organisms. The space on which sand excavated from the trenches is thrown should be five to six feet wide and the entrance path to the latrine four or five feet wide. In this case the posterior edge of each trench will therefore be nine to ten feet away from the anterior edge of the next trench. The partition walls for the seats should be four feet in length. These trenches must be given plank seats as mentioned below :—

Cross planks, 5 feet long, 1 inch thick and 6 to 8 inches wide, are placed at intervals of 6 to 9 feet across the trench. At right angles to these planks two boards 6 inches wide and 1 inch thick, are nailed parallel to each other, and to the trench at a distance of 10 inches from each other. This space of 10 inches must be directly above the trench. These planks can be stored after the fair is over and used again in subsequent years.

3. **The Removable System with Pans.**—This type of latrine with pans is most suitable for places where, owing to

rocky or stony ground, it is impossible to dig trenches. Two grass screens are erected, between which is placed a row of mud or brick seats, each provided with an iron pan or two vessels. In the case of latrines for males each seat should be partitioned off by a matting wall. The excreta and urine from these latrines will have to be removed to the trenching ground.

4. **Yellow Flag Areas.**—This type should be provided for those pilgrims who would not use latrines but prefer to go to some distance for nature's calls. A row of yellow flags should be put up at a convenient distance from the outskirts of the fair area. Within the space bounded by these flags the latrines only may be used for the purposes of nature, but beyond these flags the pilgrim may go any where he likes. Parepatetic gangs of sweepers employed for this purpose should visit these areas morning and evening and either bury or remove in baskets the filth deposited there.

Rich pilgrims should be discouraged from erecting their private latrines, owing to difficulty experienced in their supervision by the sanitary staff. If such latrines are, however, permitted, they should be licensed and allowed to be erected in accordance with the following types after charging substantial fees:—

(*a*) A pair of wooden planks on legs placed over a trench.

(*b*) A modified durbar pattern latrine consisting of an iron seat with two horse shoe-shaped apertures, one for use in the ordinary way and one for washing. Iron pans should be placed beneath both apertures.

Public Urinals.—These should be placed at the corner of each block of the inhabited side of a fair. This should be done by digging a pit 4 feet square and 5 feet deep and filling it in with road metal to a depth of 4 feet; in each corner of the square should be placed a kerosene oil tin with perforated base, and filled with sawdust previously treated with a solution of mercuric chloride, 1 in 500.

Special gangs of sweepers should be employed to remove daily all rubbish lying about the shops and roads. All such rubbish when collected should be burnt in incinerators as far as possible. Owing to a great rush of pilgrims if it is not possible to remove the rubbish to the regular collecting stations it should be disposed of in shallow trenches dug out along the edge of some of the blocks. *Bhishtis* should also be employed to water the roads.

Vaccinators should be stationed at short distances on the roads and streets to look to their cleanliness and to guide the people to use specially made latrines and urinals.

There should be proper arrangement to light the *bazaar*, streets and lanes at night, so that there might be no cases of theft, and people should not take advantage of the dark to pollute the streets and lanes by using them for offices of nature.

If any animal should die in the fair, its body should at once be carried on a cart out of the fair and buried with its skin under the direct supervision of vaccinators appointed for the purpose. At some places the Tehsil officials object to the burying of dead animals with their skins. It is, therefore, necessary to obtain definite orders on this point from the Director of Public Health, but it should be insisted that animals dying of an infectious disease must be buried with their skin.

The slaughter or sacrifice of animals should be permitted at certain places only, and every part of the animal should be carried out of the fair as soon as possible, and the places reserved for this purpose should be carefully swept twice in the day, dry earth at the same time being plentifully sprinkled where blood may have been spilled. The sweepings of these places must be carefully buried underground. If as part of a religious ceremony it should be necessary to permit a dead person or the body of a dead animal to be placed in any stream running through or past the fair, it should only be allowed below the site of the fair.

Hospitals.—At every fair where there is no permanent dispensary provision must be made for a temporary general hospital and a skeleton hospital for infectious diseases. The hospital should be placed as near the tahsil as convenient. It should be situated on a side road rather than on the main road so as to escape the dust. If a second hospital is required it should be put near the chief approach road to the fair.

The contagious diseases hospital should be placed well out in the open, but not so far away as to be difficult of access. It should not be placed on any of the main roads leading to the fair lest relations and friends may visit the patient on their way to and from the fair.

The general hospital should consist of an out-patient department and two wards, one for males and one for females. These wards should be 26 feet by 19 feet with 7 to 8 feet high walls, and covered with a pent thatched roof. Walls of *jhamp* or matting should be furnished on all four sides. In the hospital compound quarters must be provided for all the staff employed. There must also be a provision for a store godown, separate kitchens for Hindoos and Muhammadans and separate latrines for males and females. Beds must be provided for the accommodation of the sick, and in addition a few roughly made charpais for conversion into doolies.

The dispensary should be a rectangular building 36 feet long and 12 feet broad, with a plinth raised one foot above the ground level. The building should be provided with a pent roof with walls on three sides only. The fourth side should consist of matting or grass screens hinged to the under surface of the pent roof. When necessary these screens can be swung up and supported on bamboo poles so that the whole of one side of the dispensary can be opened up. The dispensary should be divided into two parts by a central screen. In each part a room 6 feet wide should be partitioned off for the examination of patients.

In addition to the ordinary hospital a nucleus infectious diseases hospital should be kept in readiness. It should

consist of three temporary grass huts, 12 feet by 17 feet, one for the Sub-assistant Surgeon on duty, one for male patients and one for female patients. Two similar huts should also be provided, one ten feet by ten feet for a godown and one ten feet by fifteen feet for the kahar dooly bearers. Shelters should also be put up for a sweeper and a *bhisti*. Two latrines with wooden seats and iron pans or earthen receptacles should be put up close to the wards. The equipment for such a hospital is four beds, a dooly, a drum of cyllin or hycol, a vessel for boiling clothes and an empty kerosene oil tin. Should an epidemic occur in the fair, the first case should be removed to this hospital and extra huts should be built as required.

For an ordinary hospital at a fair the staff required varies with the number of pilgrims attending the fair, the duration of the fair and the size of the area. For all the smaller fairs, the officer in medical charge will have at his disposal the staff of the local travelling dispensaries who for the period of the fair will be directly under his orders. This will ordinary suffice with the addition of one or two vaccinators who should be employed for the detection of infectious diseases. A menial staff of one *bhisti* and four *kahars* for doolies should also be employed. For larger fairs the staff must correspondingly be increased so that the hospitals may properly be looked after and the whole fair area adequately patrolled to discover cases of sickness.

The medical officer should visit without delay any part of the fair where the outbreak of sickness or death arising from any cause has been reported to him. The sick should be removed, if possible, with their families, to the nearest hospital, and if the disease is cholera, to the segregation hospital.

The Civil Surgeon of the district where the fair is held (whose services are indispensable on the outbreak of cholera) should ordinarily have charge of the hospitals of the fair and

visit them at least twice a day and render necessary professional aid to those admitted into the hospital and also to those who may be unable to be carried there.

At very important stations, as at Agra, Allahabad or Benares the Civil Surgeon may, at his discretion, depute a medical officer at least of the grade of the Provincial Medical Service to act for him and under his orders.

The Civil Surgeon should furnish a supply of medicines and surgical instruments for hospital use at the fairs, which would ordinarily be the equipment supplied to a travelling dispensary. The main hospital should also be furnished with a supply of blankets, a reserve stock of potassium permanganate and a drum or two of cyllin or hycol.

The travelling dispensaries or dispensaries attached to a division should be present throughout every fair held in the district.

Police.—The duties of the police at fairs are (1) to maintain a careful watch that the sanitary arrangements are fully carried out; (2) to forbid the performance of the offices of nature in or near the fair at any place not set aside for such purpose; (3) to report to the medical officer of the fair the appearance of sickness in any part of the fair; and (4) to cause all persons suffering from cholera, plague, small-pox or any other serious disease, to be removed at once to the hospital set apart for such purposes, and, if possible, to prevent the approach to the fair of any person affected by any of these diseases.

Inspection of Pilgrims.—Sub-assistant surgeons and compounders should be stationed at railway stations to inspect all pilgrims so as not to allow persons suffering from any infectious diseases, particularly cholera, plague and small-pox to visit the fair, and some special arrangement should be made to inspect those, who are coming from neighbouring villages by routes other than by rail by erecting some *chowkies* at principal roads leading to the fair area. With a view to prevent the importation of infectious diseases to large fairs

and religious gatherings held in the United Provinces of Agra and Oudh the Governor acting with his Ministers has framed the following regulations for the medical inspection of railway passengers under section 2 of the Epidemic Diseases Act, III of 1897 :—

(1) Travelling dispensaries shall be posted at Captainganj, Bhatni and Ballia stations on the Bengal and North-Western Railway and at Moghal Sarai station on the East Indian Railway between January 15 and April 15, and at Jhansi, Manikpur and Muttra stations on the Great Indian Peninsula Railway, and Ghaziabad and Saharanpur stations on the North-Western Railway if and when plague, cholera and small-pox are epidemic in those portions of India outside the United Provinces from which trains arrive at these stations.

(2) The medical officer in charge of the travelling dispensary shall pass through the trains looking for obvious signs of these infectious diseases and shall isolate cases found in huts attached to his travelling dispensary, thus to a great extent preventing the spread of infectious disease.

(3) The medical officer shall inform the station master if he has found any infectious disease and in which carriages such disease was found, in order that the latter may carry out the provisions of the Railway Act and side-track these carriages for the purpose of disinfecting.

(4) The Assistant Directors of Public Health, United Provinces, shall inspect and control these dispensaries and make adequate provision for the isolation of patients by the erection of huts, etc.

A camping-ground with a good well should, if possible, be provided at the railway stations near the fair. From this camping-ground to the site of the fair a pilgrim route should be laid down so as to avoid large towns, and camping-grounds should be provided at proper distances, of a day's march, apart on the line of road. Arrangement should be made for supply of sufficient and good healthy food, and fenced trenches for conservancy purposes with two sweepers should be provided,

and a party of police should be appointed to have the charge of each camping-ground. A hospital space should be set aside at each camping-ground where patients suffering from cholera or other infectious disease should be removed for treatment, but they should not be allowed to proceed with other pilgrims, and the pilgrim route should at once be diverted from the camp into some other road, a new camping-ground being provided to which the camping pilgrims should be directed.

Two sweepers should be attached to each considerable camping-ground to cover in the trenches after they have been used, to provide new trenches, and to bury carefully the excretions of patients admitted into the hospital. Similar arrangements should be enforced on all main lines frequented by travellers to the fair.

Lodging Houses.—These are defined as houses or parts of houses in which pilgrims are lodged for hire, for any term less than a week at a time. After inspection and approval by the Municipal Board each must be registered in the name of the keeper. Executive officers should be authorised to inspect these houses and to see that pilgrims are not housed by any other persons not holding a municipal license for the purpose. It should also be seen that there is no overcrowding in these lodging houses, and that the number of pilgrims in each room does not exceed the sanctioned number. The rooms must be kept clean and well ventilated, and notice of any case of infectious disease must at once be sent to the health officer. The latrines attached to these houses should be kept thoroughly clean, for which purpose a number of sweepers in proportion to the accommodation of the pilgrims should be permanently maintained on the premises. Besides the executive officer, the health officer should be authorised to inspect such houses, to look to their sanitary arrangement, to investigate cases of sickness and to disinfect them in the event of a case of an infectious disease occurring therein.

At the time of the fair an officer authorised by the municipal authority under section 6 (1) of the U. P. Lodging House Act, 1892, should be specially deputed to inspect these lodging houses.

Water-Supply.—If possible, an arrangement must be made for a piped water-supply. Where this is not possible, all wells likely to be used by the pilgrims should be cleaned and disinfected with potassium permanganate, a week before the commencement of the fair and twice a week during the fair, but should be disinfected daily on the outbreak of epidemic cholera. Any wells thought to be dangerous should at once be closed. To further protect these wells, individuals should not be allowed to lower their *lotas* or *dols* into them, but *kahars* should specially be appointed to draw water from each well and should be provided with sufficient *matkas* so that they could serve the pilgrims with water through *piaos, i.e.*, furnish water by pouring it into a hollow bamboo or tin *parnalla*, below one end of which is presented the water vessel which requires filling. This arrangement will not be satisfactory for large fairs where *kahars* will not be able to cope with the work owing to a rush of large crowds for water. In such places it is advisable to close the mouth of the well when the water is not over 25 feet from the surface, and the water should be pumped out by *kahars* into cisterns provided with water taps. Tube wells with a pump attachment sunk into the soil where the subsoil water is 20 feet below the surface are often very satisfactory. If the fair is held near a river or a running stream, it should be the duty of the police to see that sweepers do not pollute river water by throwing excreta and refuse into it. People should be persuaded not to drink river water as far as possible, but should use disinfected well water at those places where there is no municipal water-supply.

Food-Supplies.—A sanitary inspector or sub-assistant surgeon should be appointed to inspect food-supplies. He should work under the orders of the medical officer-in-charge of the fair. Old, stale, indigestible and improperly cooked

food, and unripe and over-ripe fruits should be destroyed, but except in emergent cases, the order for destruction of such food should be obtained from the administrative officer-in-charge of the fair. If necessary, vendors of bad and unwholesome food should be prosecuted under section 273, I. P. C. (*Vide* Appendix C). Sweetmeats, *puries* and other eatables offered for sale should be well protected with wire-gauze netting or even ordinary clean cloth from flies to avoid infection with cholera germs.

Epidemic Diseases.—The most important duty of the medical officer-in-charge of a fair is the early detection of any case of infectious disease occurring in or near the fair or in the lodging houses of the town near the fair. The following precautions should be taken to guard against an outbreak of an epidemic :—

The whole of the fair area should be divided into conveniently sized blocks and each block should be placed under the direct supervision of a sub-assistant surgeon, sanitary inspector or vaccinator whose duty will be to go over this area and report at once to the medical officer of the fair the occurrence of any case of infectious disease or any other suspicious illness. Volunteers of the Friends of India, etc., may also, with advantage, be employed for this purpose. Sweepers in charge of latrines should be required to make daily reports, so that the occurrence of an unusual amount of diarrhœa or any other similar disease may be brought to the notice of the medical officer of the fair without delay. Arrangements should also be made for the constant inspection of latrines and patrolling of fair areas in order to discover cases of sickness, as pilgrims suffering from diarrhœa or dysentery will not resort of their own accord to hospitals for treatment.

For the removal of the sick *doolies* should be provided at the hospitals and police outposts in the fair and gangs of *kahars* should be employed to carry these *doolies*.

Disinfecting gangs or their nuclei should be kept in readiness and provided with lime or bleaching powder, bottles of disinfectant, pails for mixing the disinfectant and syringes for spraying. As soon as a case of cholera is discovered one of these disinfecting gangs under the charge of a reliable officer should proceed to the place and disinfect it by sprinkling the whole surface with a solution of 1 to 150 of hycol or cyllin, by removing 2 inches of soil and covering the area with a layer of lime or bleaching powder. All *gamlas* should be destroyed and metal vessels should be disinfected. The contacts of the first few cases and as far as possible of all cases should be isolated and their clothes should be disinfected. The clothes of the sick or deceased person should be destroyed or disinfected very thoroughly. Compensation should, where this is desirable, be given for the clothing that is destroyed. The patient should be removed to the hospital where his excreta should be passed into a solution of 1 to 150 of hycol or cyllin. To provide against carelessness on the part of the sweepers it is safest also to boil the excreta in a kerosene oil can and to bury them three feet under ground.

Disinfection for infectious diseases other than cholera should be carried out on the usual lines by burning the huts and boiling or otherwise disinfecting the clothes. At the infectious hospitals of the fair arrangements should be made for the disinfection of the clothing of contacts by heat. A large iron vessel *(karahi)* should be provided and the clothes placed in boiling water for a few minutes, wrung out and returned to the wearers.

Epidemic Cholera.—If cholera should appear in an epidemic form at any fair, a telegraphic intimation should be sent by the officer-in-charge of the fair to the Director of Public Health, to the magistrates of all the surrounding districts and to the Government, while the magistrate of the district should give intimation by a demi-official letter or telegram to all magistrates and political agents of localities where disease-stricken people are likely soon to arrive. The Director of

Public Health should also inform the Director of Public Health of neighbouring provinces. The officer-in-charge of the fair should then encourage the pilgrims assembled at the fair to disperse to their homes with the least possible delay.

As soon as the Magistrates of surrounding districts receive the news of the outbreak of cholera in the fair, they should enforce such measures as might be necessary to prevent the passage of a numerous body of pilgrims through any large town or cantonment in their respective districts. If the usual road of such pilgrims lies through any large town the Magistrate should establish a commodious halting place with a good well near to the most convenient way or road by which the pilgrims may pass on their route outside the town, as directed by the police force detached for that duty. A plentiful supply of the ordinary articles of food will be sent out to the camping ground. Such of the pilgrims as belong to the town should be required to encamp there for one week before they can be permitted to enter the town, and then only in case of no appearance of the disease in the camp. If cholera occurs among the pilgrims so encamped a hospital similar to a fair hospital should be established. Provided the water supply and food are properly protected from contamination, it will be rarely necessary for the general body of pilgrims to be removed to another distant camping place, to pass a second week in quarantine. Paupers should be provided with a daily ration of food at the public expense.

Pilgrims coming from a place where cholera is known to be raging in an epidemic form, should be prevented from visiting the fair.

If it is found necessary to close the fair owing to the prevalence of cholera or other infectious disease in an epidemic form, the fact should be notified to the public by the Civil authorities, and the railways should not run any special trains to the fair, should withdraw all other facilities which are usually provided for the convenience of the traffic on such occasions, should post up, at conspicuous places on all stations,

a notice to the effect that the fair has been stopped, and should require the booking clerks to warn intending passengers of this fact.

FAMINE CAMPS.

The following sanitary and medical arrangements as regards huts, conservancy, water-supply, etc., should be observed for famine camps to be erected for relief works in a famine-stricken district.

Huts.—To give shelter to the workers screens[1] should be put up, which should be about 6 feet long and 4½ feet wide, made of very open bamboo trellis work strongly tied, and thatched with about one inch thickness of any thatching grass available. Six to eight persons can be accommodated with two such screens. *Sirkhi* screens may be used as a substitute for grass in those places, where they are easily obtainable.

Grass huts, 9 feet by 9 feet with the ordinary pent roof prolonged 3 feet beyond the door end of the hut, should be supplied to officials connected with the works, for whom tents cannot be provided. The walls should be plastered with mud on the inside and all other surfaces should be whitewashed, both inside and out, with a thin wash of equal parts of clay and lime, as a protection against fire. The mud plaster and whitewash should be renewed at intervals. The two roof *tattis* and four wall *tattis* should be made in sections so that they can be readily dismantled and re-erected when necessary. The height of the sides should be four feet only. Any extra height required may be obtained by digging out the floor. It may be remarked that the hut with a dug out floor is markedly cooler than one on the ground level with the full height of its wall exposed to the winds.

Hospitals.—No special hospital arrangements are necessary if a famine camp is situated within two miles of an existing branch dispensary; for the sub-assistant surgeon and his staff can daily inspect the camp, treat trifling cases on the

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1. *Vide* the Revised Famine Code, U. P., 1912.

spot and can remove serious cases to the dispensary, where the accommodation, if insufficient, can be increased to any extent by the addition of grass huts. However, a separate sub-assistant surgeon should be appointed in case any epidemic disease should break out.

Where a famine camp is situated beyond the reach of an existing branch dispensary, two hospitals, 25 feet by 16 feet with walls 8 feet high, should be provided—one for males and the other for females. Two isolation huts, each 10 feet by 10 feet, should be kept ready. The sub-assistant surgeon in charge of the hospital should be provided with a hut divided into two rooms, of which one will serve as a dispensary. There should be a separate hut for the hospital kitchen. Two small mat enclosures—one for males and one for females—should be put up at a little distance from the hospital to act as latrines for the patients; if the huts are surrounded by an enclosure wall, one side of the wall should be made of mud or clods with a gateway in the middle to enable the patients to escape in the event of fire. The abandoned hospital should immediately be burned to the ground; if patients suffering from any epidemic disease have been admitted into it, the site should be sprinkled with about six cubic feet of quicklime, sifted evenly over it, the whole being well sprinkled over with water until the lime is thoroughly wet.

Conservancy.—The conservancy of every hospital should be carried out by its own staff of sweepers under the directions of the medical officer-in-charge. The usual latrine of screens and ditch should be provided for the staff. Similar latrines should be provided for workers on works near a large town. On works not near a large town, a line of yellow flags about 100 yards apart should be set aside on each side of every road work and round every tank or quarry work, and every camp and hospital, and at a distance of not less than 150 yards from the work or camp. The ground within these flags must be kept clear of all nuisances, and a few sweeper patrols

should be posted to insist on the workers going at least outside the flags for calls of nature usually in the mornings. The people should generally go to the east of the work; but if there is a village near on that side, they should be asked to go in another direction.

There should be a proper arrangement for the disposal of the dead, and this becomes much more necessary in the case of an epidemic outbreak. At every three or four miles of a relief work there should be a burning place for Hindus and a burying place for Mahomedans. The two places should, if possible, suit the local customs; they should be far apart, and neither should they be near the village nor within half a mile of the work. Each should have a small staff.

If friends are willing to dispose of corpses according to their various customs, they may be assisted with free firewood or ready dug graves; but in other cases the bodies must be disposed of properly. At the police guard or other convenient place there should be arrangements for the cremation, free of charge, of every Hindu body which friends are not willing to burn or otherwise dispose of. For the Mahomedan cemetery, there should be one or two grave-diggers, who should keep a certain number of graves ready dug. The graves should be not less than five feet deep and the dead bodies should be completely and decently covered in. It should be the duty of the police to take charge of all unclaimed bodies for their proper disposal. In epidemics every effort should be made to burn the bodies.

Water-Supply.—In dealing with water supplies to famine camps it is necessary to bear in mind that water should be disinfected at its source and that it should be subjected to as little handling as possible from the source to the consumer to avoid liability of infection especially by cholera carriers. It is therefore necessary to guard all the adjacent wells from contamination for some days before a charge is opened. Some respectable, cleanly and reliable man of a high caste should be appointed as foreman of the water arrangements. He should have four or five Brahman mates, a *Kahar* mate, about 20

Kahar carriers and the same number of Brahman drawers and distributors under him. He should take possession of all the wells close to the future work a week or so ahead of the workers, disinfect them at once with potassium permanganate, fence them round with a high bamboo trellis, and at once put each in charge of a Brahman with one or two assistants. He should also see that they observed the following instructions for drawing water from wells :—

These men should draw water for any one who requires it, and should not allow any one else to go on the well platform. Water should be drawn by providing a large iron pulley and two iron *dols* (having a capacity of two gallons), one of which should be affixed to each end of the rope, or one *dol* and a slightly heavier counterpoise weight at the other end of the rope, so that the rope and *dols* should never leave the interior of the well or its platform. When a large amount of water is required to be drawn from a well, situated at a distance from a village, a four gallon *dol* might be drawn from the well by two or three *Kahars* hauling on a rope. But in that case the whole of the area traversed by the rope must be surrounded by bamboo fence interwoven by thorn bushes. The rope also should overnight be soaked in permanganated water.

Kerosene oil tins should be used for carrying water. These tins should be strengthened with an iron strap round the top and furnished with an iron handle. Half of the top should be cut away and hinged on again to prevent water splashing out. If water has to be taken a long distance, it is best to carry it in casks fitted with brass cocks and loaded two in a cart.

The actual distribution of water is best effected by setting up *piaos* or drinking places at short distances apart. A large earthen jar called a *gol* should be set up a little aslant on a low mud platform. By the side of it a narrow sheet iron trough some four feet long should be set up on two stakes on a slight incline with the further end about two feet above the

ground. This trough should always be made of iron, for it will by rust and heating in the sun almost certainly disinfect itself in a short time, if it happens to get infected. These drinking places should be distributed in the manner most convenient for the workers and close to their work; along a roadway it is most convenient to place one at every second furlong and close to the road, but not within 20 feet of it. A similar procedure should be adopted in the case of tank and other works.

The water *kahars* should fill the jars from the kerosene oil tins and no one else should touch them. The Brahman distributor will sit by the side of the jar and when anyone comes for water, he will fill his brass pot or *lota* holding it by means of a split bamboo stick, about 1½ feet long, and pour water into the man's *ghara* or pot by means of the trough but not direct. The practice of drinking water direct from the trough should be discouraged, as it may cause infection and always involves waste of water. The work people should be supplied with *gharas* for the storage of water, and smaller pots for drinking. If they have not got them, they are apt to drink direct from the trough in the day, and to wash and even drink at dirty ponds or tanks at night or in the early morning. The large jars or *gols* should ordinarily be broken up on departure, and new ones should be purchased at each new place. If new jars are not available, the old ones may be used again, but must first be disinfected with a small amount of potassium permanganate. The deep red permanganated water should stand in them for six hours and then be poured off.

Where possible, an arrangement should be made to run water-carts at frequent intervals up and down the works. A Brahman should distribute the water from the carts.

If there are more wells than are required, the unused ones should be guarded as should also be all doubtful or tainted wells. All small ordinary wells in use should be treated with one ounce of potassium permanganate on Sundays and

two drachms every day. Wells with a wide cylinder and containing over six feet of water should be disinfected with two ounces of potassium permanganate on Sundays and four drachms daily.

When wells are absent or are brackish, and water is obtained from rivers, streams or pools, it should be poured into cisterns provided with a stop-cock or into large earthen *gharas*. If loaded with silt, it should be treated with 6 grains of alum to the gallon. It should then be disinfected with potassium permanganate. When streams are liable to be polluted, *katcha* wells should be sunk in the banks. They would, in all probability, yield the desired amount of water, which should be Hankinized before use. The wells and their vicinity must be carefully protected from contamination.

At each charge Nesfield's water sterilizing powders should be kept in stock ready for use in disinfecting wells and drinking water on the outbreak of disease, especially cholera.

When cattle have to be watered at wells in addition to the supply to the workers, a mud stall should be raised a short distance from the well and *naunds* placed in it. These *naunds* should be connected up to the platform and to each other in sequence by iron or tin *parnallas* which should carry the water spilled on the platform to the *naunds* and the fencing and thorn hedge round the well carried up to the edge of the drinking trough.

Food-Supply.—For the supply of food there should be a small market consisting of two rows of huts made of shelter screens, with a 20-feet roadway between them and a fence of light bamboo trellis round them with openings at the ends of the street. The quality of the food should be frequently examined and immediate action should be taken against any one found selling unsound food. The unwholesome pulse called *khasari* or *kesari* should not be admitted into the market.

POOR HOUSES.

These are institutions where cooked food is distributed gratuitously to the inmates, who are poor and unable to go to relief works owing to physical debility or illness; but lepers should not be admitted into them. However, if lepers have no fixed homes, they should be kept in isolated huts at a reasonable distance from the poor houses. They should be situated in a grove on a tolerably high and dry land about one mile from the headquarters of the sub-division and there should be an ample supply of water for drinking and bathing purposes.

Buildings.—The enclosure wall should preferably be made of mud. If it is necessary to use grass or hurdle screens as walls, they should be plastered with mud as a precaution against fire. There should at least be two main exits from the poor houses not less than 8 feet wide; and no thatched or inflammable material should be employed in any structure within 50 feet on either section of the exits. A number of *gharas* filled with water should be kept ready for use in the case of fire.

The shelter may consist of long sheds, running along the enclosure wall, or of separate huts. Huts are cleaner, safer and more convenient, though somewhat more expensive than shades. A few huts should be isolated by a bamboo fence to keep new arrivals under observation. Open sheds in front of the huts or sheds should be constructed for feeding or working, as necessary. A thickly thatched hut should be kept separate for storing water. The walls of the cook-house, store-room, office and clerk's house should be made of unbaked bricks and the roof should be a tiled one.

To every poor house should be attached a hospital with sufficient accommodation for a reasonable proportion of the total number of the inmates, both male and female. It should usually be placed at a reasonable distance from the paupers' quarters, but always as near the poor house as is consistent

with health. The hospital should be in charge of a sub-assistant surgeon, who should be provided with accommodation. Separate, dry and well ventilated huts for the reception of infectious diseases should be constructed at a reasonable distance from the poor house to secure a complete isolation. Both the hospital and segregation huts should have their own separate latrines. A small latrine should also be erected separate for the staff.

Food-Supply.—The food should be distributed twice a day, unless the district medical officer with the sanction of the Collector directs that only one meal a day be given. The flour should be of the best quality, as the presence of husk, or any foreign matter may give rise to intestinal complaints such as diarrhœa and dysentery. It should be carefully weighed out for cooking, and the pulse should contain a quantity of pepper and spices according to local custom.

Freshly prepared and warm *chapatis* should be issued to the very old and toothless inmates, as they are easy to digest; and previously prepared ones, which have become cold and heavy, to the more robust.

Water-Supply.—Drinking water should be drawn from a well outside the poor house. The well should be carefully guarded against contamination, and no one should be allowed to draw water from it except persons of high caste appointed for the purpose. The water required for use during the day should be stored in iron vessels or earthen jars in the water house, from whence water should be supplied by means of a *piao*, with a metal channel or pipe to persons requiring it. None except the water carrier should have access to the water house.

There should be a separate well for bathing and washing clothes at some distance from the poor house and the drinking well. It should have two troughs—one for bathing and the other for washing clothes.

Latrines.—Two night latrines with earthen or iron receptacles should be provided inside the enclosure. Other latrines are best provided on the trench system with a moveable screen. They must be at a sufficient distance but not too far away. Boys or able-bodied individuals should be told off to help very old, blind and lame inmates to latrines, etc.

Every inmate should be provided with a piece of *chatai* to sleep on, spread over the grass or straw in the hut, and he should expose it to the sun on both sides for about an hour outside the hut. The grass and straw should be similarly removed, shaken up and exposed to the sun twice a week. Stout "gunny" cloth may be provided if blankets are not available."

DISEASES LIKELY TO OCCUR DURING FAMINE AND THEIR PREVENTIVE MEASURES.

1. **Diarrhoea and Dysentery.**—Owing to extreme hunger people eat anything that comes to their hands and so they generally suffer from intestinal troubles. Those that are removed to a poor house in a weak and exhausted condition, start eating *chapatis* or any other solid food, and consequently contract diarrhœa and dysentery. To such persons it is, therefore, better to give boiled rice and *dal* for the first few days until their digestive power has improved. Special care should be taken in dieting children and old people on their first arrival into a poor house. *Dalia* soup is very good for constitutions weakened by starvation. It is made by mixing one *seer* of flour with five seers of water and one *chatak* of salt, the mixture being boiled down to about 4 seers.

2. **Deaths due to Starvation.**—In order that people should not die of starvation, the Superintendent of Police should organise a system of patrols for the lanes and the bye-ways of towns and villages, and for temporary rest-houses or *sarais* on trunk and district roads, for conducting starving wanderers to the nearest relief work, poor house, police station

or outpost. He should also make arrangements to provide such wanderers with food in transit. Private charities should also be directed to this end.

3. **Cholera.**—If cholera breaks out in a relief work the following measures should be adopted :—

1. Cholera cases should at once be removed to an isolation hospital. Contacts should be removed to segregation huts.

2. All infected materials, such as old clothes, rags, etc., belonging to the sufferers or those in contact with them, should, if possible, be burnt or, at any rate, should be thoroughly disinfected. *Chappars*, small huts, and all materials used for bedding, should be burnt.

3. All the water supplied to the staff, workers and dependents should be treated as follows :—

Sterilization stations should be selected on the roads to the wells. At each station a special *kahar* sterilizer should be appointed. Each station should be provided with two *matkas*, a zinc pail, one bottle each of A, of B and of C of Nesfield's solutions and two small measuring cups of tin made of the exact size to sterilize the water in one cistern and one pint enamel cup.

Every cart proceeding to a well visits the sterilization station. The sterilizer empties one measure of solution B into a pint enamel cup and pours it into a bucket of water, mixes up the solution and empties the bucket into the cistern on the cart, which then proceeds to the well and is filled with water. On the return journey the cart again visits the sterilization station, where the above operation is again repeated, one measure of solution C being used in place of A and B solutions. A separate cup is used for A and B and C as traces of "C" neutralize A and B. This cup should be painted a distinctive colour. The cart then proceeds to the *piaos* and on its return empty again visits the sterilization station. This process should be carried out in addition to the usual permanganisation of wells and *matkas*.

The solutions A, B and C are of such a strength that five drops of each are required to the gallon of water. If fifty gallon cisterns are in use, the tin measure should be constructed to contain 250 minims, *i.e.*, nearly half an ounce.

In most cases no further action is necessary, but if cholera persists for over six days, the charges should at once be removed from the infected area and the sterilization of water should be repeated.

4. If cholera cases still occur in the first five days after removal, the charges should be broken up in as small a unit as is compatible with supervision and discipline.

5. The water supply on the new ground should be carefully selected and rigidly protected, search parties being sent in advance for the purpose. All water supplies should be disinfected with potassium permanganate forty-eight hours before use.

6. Nesfield's tablets are quite suitable for the individual use of camp officers using a small amount of water, or all water used for drinking and washing up of dishes, etc., may be boiled. Boiled water should, as a rule, be used within twenty-four hours, and should be carefully protected from dust and contamination. Officers should see that their servants dip their soup-straining clothes and *jharans* into boiling water before use.

7. Hot, cooked food should preferably be eaten and all milk should be boiled. Ten drops of dilute sulphuric acid are recommended to be taken twice a day during the epidemic of cholera.

8. All latrines and discharges should be disinfected with a free use of phenyle or cyllin (1 in 200).

9. The site should be kept scrupulously clean.

If a poor house is infected by cholera, the undermentioned measures are necessary to adopt :—

1. The water-supply should at once be changed, the former source of supply being effectually closed. The new wells should be permanganated before use.

2. All food (except grain actually stored in the poor house at the time of the occurrence of the outbreak) should be destroyed.

3. Six inches of earth should be removed from the floor of the barracks. If the roof be thatched, it should be burnt.

4. The trenches in use should be filled up, the grass screens burnt and a new latrine erected on a new site.

5. All drains should be washed down with a solution of mercuric chloride (1 in 1,000) and hydrochloric acid.

6. If there is overcrowding, the inmates of the least infected barracks should be separated into small gangs; and any gangs remaining free from disease after five days should be drafted off to a suitable locality after bathing and having their clothes thoroughly disinfected.

4. **Plague.**—As a precaution against plague, workers on relief works should be inoculated with Haffkine's serum. Eatables should not be allowed to be exposed, so that rats might be attracted. There should be an arrangement to trap rats if there are any, and mates of gangs should be instructed to report if any rats are found dying.

5. **Small-pox.**—If any cases of small-pox occur, they should at once be removed to an isolation hospital; contacts should be segregated, and attempts should be made to vaccinate or re-vaccinate them as the case may be. The other workers should, if possible, be all vaccinated, except those who might have suffered from small-pox previously. The clothes and bedding belonging to small-pox patients should be destroyed and the hut or huts occupied by them should be dismantled and burnt if possible.

6. **Relapsing Fever (Famine Fever).**—The Sub-Assistant Surgeon should be well acquainted with the symptoms of relapsing fever. The occurrence of a relapse in fever after a remission of a week should excite his suspicion. The fourteenth day after the commencement of a primary

attack followed by a remission is the one upon which the relapse is most likely to occur.

As soon as a case of relapsing fever is detected, he should be isolated, and his clothes should be thoroughly disinfected. It is now an admitted fact that the germs of relapsing fever are chiefly carried by body lice in the clothes and beddings of the patients, and so people should not be allowed to wear one another's clothes, and they should wash and keep them clean, so that they might not be infested by lice.

7. **Scurvy.**—The gums of all the inmates of a poor house and those on relief work should be examined for scurvy, to prevent which, the issue of a ration of vegetables twice a week is very desirable. In the absence of vegetables *amchur*, fleshy calyx of *patwa* or fresh limes, should be given. If ulcers are found on the legs or other parts of the body, they should be promptly treated.

8. **Malaria.**—Quinine sulphate should be distributed once a week to persons employed on relief work and inmates of poor houses. The camps should be situated on a well-drained site, so that there should be no undue accumulation of water for the anopheles to breed ; and workers and inmates should not unnecessarily keep *gharas* filled with water or there should be no pools near wells where water may be clogged. Besides these, there are other diseases incidental to want of food, but they need not be discussed here.

CHAPTER XXVI.

VITAL STATISTICS.

VITAL statistics may be defined as the science of figures applied to the life histories of communities or nations. They refer to those events which have to do with the origin, continuation, and termination of the lives of the inhabitants. They ordinarily relate to the numbers of the population, of their births, deaths, marriages, diseases, the duration of their lives, and to some extent their social and mental condition. The recording of these statistics is very necessary, so that we may know the rate at which the population in different parts of the country is increasing or diminishing and the causes that tend to this increase or decrease. In India these are computed in the office of the Director of Public Health of each province from the returns forwarded by the District Mortuary Registrar during the first week of every month, and are expressed in terms of the population, usually as rates giving the number for each 1,000 inhabitants. The District Mortuary Registrar is the Health Officer of a municipal town or city.

THE CENSUS.

This is an enumeration of the population which has been taken regularly every tenth year in the United Kingdom with increasing care ever since 1801. In India the census was first taken in 1851, was then taken every fifth year till 1871, and since then has been taken every tenth year. The last census was taken on the 18th of March, 1921. In taking a census it is desirable in so far as possible to take it at a time when the greatest number of people will be at their homes; hence the time selected is usually midnight. The enumeration of all, who are travelling, as well as vagrants, is taken at the same time. It shows the number of *pucca* and *kutcha* houses, the number

inhabited, the individual particulars about sex, age, religion, conjugal condition, educational state, language, tribe, caste, nationality, occupation, and infirmity. In spite of every precaution taken there is always a possibility of many errors creeping in, the chief of which are regarding the age, caste and occupation. These errors are either due to the carelessness of the enumerators, or due to the ignorance of, or the intentional fraud on the part of, the people.

Population.—Populations are constantly changing. Emigration and immigration are the two principal factors which contribute to these changes. Migration not only may affect the population of a country as a whole, but also may alter the distribution of people within a country. Owing to the increase of industrialism and irregularities in rains many young adults of both sexes migrate from rural areas to the cities, and from one locality to another in search of work. Again, populations are also being increased by births and suffering losses by deaths. The rate of change, however, resulting from births and deaths, is usually comparatively constant or alters gradually, while the changes due to migrations may be exceedingly irregular.

The exact information about the population is obtained from the census taken every tenth year, but the information about the intervening years can be ascertained by the following four methods :—

1. The method adopted by the Registrar-General of England and Wales is based on the assumption that the increase or decrease of the population has been fairly uniform since the last census at exactly the same rate as between that and the previous rate. This is, of course, in geometrical progression, and may be compared to the accumulation of money at compound interest.

Assuming a ten-yearly census, let

P = the population in 1901,

P^1 = the population in 1911,

R = the annual increase per unit of the population,

Then the population would be—

In $1902 = P(1 + R)$

In $1903 = P(1 + R)^2$

In $1904 = P(1 + R)^3$

In $1911 = P(1 + R)^{10}$

$$\therefore \frac{P1}{P} = (1 + R)^{10}$$

$$\therefore \sqrt[10]{\frac{P1}{P}} = 1 + R \text{ and } R = \sqrt[10]{\frac{P1}{P}} - 1$$

In practice, the calculation is made with a table of logarithms, and given the value of R the estimated population per any inter-censal or post-censal year is readily obtained.

2. The second method consists in estimating the population by multiplying the number of inhabited houses by the average number of persons per house, as deduced from the last census.

3. The third method for calculating the population is from the birth-rate on the assumption that it remains constant every year. The following formula is used for the purpose :—

$$\frac{\text{Number of births in the year} \times 1{,}000}{\text{Birth-rate per 1,000 in the last census-year}} = \text{Population.}$$

4. The fourth method can be adopted only if complete records of births, deaths, emigration and immigration are kept after a primary enumeration, but this is not practicable in most cases.

REGISTRATION AND COMPILATION OF BIRTHS AND DEATHS.

To secure accuracy it is essential that there should be a double compulsory report of these events on the one hand by the public at a recording station in a municipal town or city, and on the other hand by the sweeper to the officer in immediate control of them who, in addition to recording the reports, should also exercise a check on the information given. According to the United Provinces' Municipalities Act, 1916, it is compulsory for the head of every family resident in or on

a visit to the municipality, and the keeper or person in charge of every lodging house, *dharamsala*, *sarai*, hospital or other similar institutions therein, to report within three days the occurrence of any birth or death in his family or among persons staying in the same premises. It should be remembered that births include still-births, but they are entered in a separate register.

In registering births the following particulars are noted :—

1. Date and time of birth.
2. Name (if any) of child.
3. Whether still-born.
4. Name of father or mother.
5. Sex.
6. Caste.
7. Profession of parent.
8. Name of muhalla. Number of house according to door-plate.
9. Name of reporter.
10. Signature of recording officer with date.

The following particulars are noted in registering deaths :—

1. Date and time of death.
2. Name of deceased and name of father, husband or guardian.
3. Sex.
4. Caste and profession.
5. Age.
6. Cause of death attested by a medical practitioner in case when a medical practitioner is in attendance.
7. Name of muhalla. Number of house according to door-plate.
8. Place of cremation or burial.
9. Name of medical practitioner who attended deceased during last illness.
10. Name of reporter.
11. Signature of recording officer.

When the cause of death is not ascertained by registrars from the symptoms described by the reporter, it is generally entered as "Not known."

Birth-rate.—This is stated as the number of births occurring during a year per 1,000 of the total population

estimated at the middle of that year (mean population). It is obtained by multiplying the number of births in the year by 1,000 and dividing the result by the mean population. This is known as the crude birth-rate. A more satisfactory method of calculating the birth-rate is by estimating the number of births occurring during the year per 1,000 child-bearing females between the ages of fifteen and forty-five.

The birth-rate is generally affected by the habits and customs of the people, by their desire to have children or their desire not to have them. Also a high infant death-rate is usually accompanied by a high birth-rate, and, conversely a low infant death-rate by a low birth-rate.

The birth-rate is higher in towns owing to a higher marriage rate, the earlier age at which women marry, and the high rate of infant mortality. The commercial prosperity increases the birth-rate owing to an increased number of marriages. The birth-rate is high in large industrial centres. It has also been noted that the birth-rate is higher among the poor people than among the well-to-do people.

The greater number of births takes place during the first half of the year. The male births exceed the female in the proportion of 104 to 100, but before the end of the second year the numbers are almost equal owing to the greater mortality among male infants.

Death-rate.—In India there is no rule of not allowing a dead body to be buried or cremated, unless a death certificate from a registered medical practitioner is forthcoming, as is the case in England and other countries. It is also not possible to introduce this rule for some years to come, as the number of registered medical practitioners is much too small for the population.

The death-rate is ordinarily calculated by the following equation :—

$$\text{Annual death-rate} = \frac{\text{number of deaths in the year} \times 1{,}000.}{\text{Population in the middle of the year.}}$$

In the same way weekly, monthly and quarterly death-rates may be calculated from the following equations :—

$$\text{A weekly death-rate} = \frac{\text{number of deaths in the week} \times 52.17747 \times 1,000.}{\text{Population.}}$$

$$\text{A monthly death-rate} = \frac{\text{number of deaths in 4 weeks} \times 13 \times 1,000.}{\text{Population.}}$$

$$\text{A quarterly death-rate} = \frac{\text{number of deaths in the quarter} \times 4 \times 1,000.}{\text{Population.}}$$

The death-rate calculated in the above-mentioned manner is called the *crude* or *gross* death-rate. The death-rate obtained by deducting the number of deaths occurring among strangers admitted into large hospitals or asylums and by adding those of natives dying out of the district is known as the *recorded* death-rate. It is known as *corrected*, when it is calculated in accordance with the age and sex distribution of the population, as also non-resident or migratory persons.

The standard death-rate is the average death-rate at all ages for the previous decennium, and is obtained by multiplying total deaths thus calculated by 1,000 and dividing by the number of the population. The factor of a particular town can be obtained by dividing the standard death-rate of a country by the standard death-rate of that town.

The comparative mortality figure represents the corrected death-rate in each town compared with the recorded death-rate at all ages in a country, *e.g.*, England and Wales taken as 1,000.

The death-rates are mostly influenced by the various direct and indirect causes of disease, *e.g.*, age, sex, race, locality, season, climate, occupations, etc.

Zymotic Death-rate.—This is the number of deaths from the seven chief zymotic diseases multiplied by 1,000 and divided by the population. The seven chief zymotic diseases are small-pox, measles, scarlet fever, "fever" (*i.e.*, typhus, simple and continued fever, enteric), diphtheria, whooping cough and diarrhœa. The zymotic death-rate is regarded by many as a guidance to judge the sanitary condition of a

locality, but this can be better judged from the death-rate of every communicable disease separately considered. It will also be helped very much by considering the specific death-rates showing the incidence of death by age groups, sex, occupation, etc.

Infantile Mortality.—Infantile mortality is stated to be a proportion of deaths of infants under one year of age to the total number of births registered during the year. The rate of infantile mortality is obtained by multiplying the number of deaths of infants under one year by 1,000 and dividing by the number of births registered during the year.

The infant mortality rate during the last fourteen years in Lucknow is given below :—

Year.	Rate per 1,000 births.
1914	307.99
1915	317.81
1916	281.53
1917	295.20
1918	390.18
1919	315.75
1920	292.73
1921	330.66
1922	282.89
1923	284.90
1924	300.10
1925	260.11
1926	286.63
1927	256.46

MATERNITY AND CHILD WELFARE.

It is estimated from the Census of India for 1921 that about two million babies die every year in comparison to a few thousands in England. In fact one out of every five babies born alive dies before it is one year old. The number of still-births is also very heavy. Available statistics show that over 40 per cent. of the deaths of infants occur in the

first week after birth and over 60 per cent. in the first month.[1] Infants are considered "the assets of a nation", and every endeavour should be made to prevent such an immense and needless sacrifice of innocent lives. It is, therefore, very essential to consider the causes of infant mortality and to suggest the remedial measures for the same.

Causes of Infant Mortality.—The causes which bring about a high rate of infant mortality may be conveniently described under the following three heads :—

1. Ante-Natal Causes.
2. Natal Causes.
3. Post-natal Causes.

It should, however, be remembered that some of these causes are common to all the three periods of existence.

1. **Ante-Natal Causes.**—These are the diseases of the mother which either produce abortion or cause premature births, and consequent deaths of infants. It is an admitted fact that a strong healthy, fully developed mother will give birth to a normal healthy baby, while a sickly, ill-developed mother will naturally give birth to a weakly child, which has a very little chance of living an independent life. Syphilis and gonorrhœa are the chief causes of still-births. It should be remembered that tuberculosis is not hereditary, but a baby born of a tuberculous mother runs a greater risk of contracting the disease in its infancy. Diseases of the mother, such as anæmia, chronic renal diseases, etc., are also some of the causes of a high infantile death-rate. Intemperate habits of the mother lead to prematurity and disease of infants. Lead either destroys the fœtus in utero and causes abortion, or gives rise to premature birth. But fortunately lead is not used so largely in India as in European countries.

The employment of pregnant women in factories and mills is detrimental to their health and also to the well being of their unborn infants.

1. Census of India, 1921, Vol. I, p. 132.

Some women are in the habit of suckling their babies till they become two or three years old, and sometimes, continue to suckle the former baby during the next pregnancy, so that the baby becomes emaciated for want of sufficient nourishment, and the new infant is born in an immature debilitated condition unfit for survival. In addition the mother herself suffers in health owing to a drain of prolonged lactation on her strength.

2. **Natal Causes.**—The chief of these causes which are responsible for high infant mortality are (*a*) ignorance, (*b*) social customs and (*c*) poverty.

(*a*) **Ignorance.**—This should be ranked first among the natal causes of infant mortality in India. Women in India are mostly ignorant and illiterate, and being conservative by nature adhere to old fashioned and superstitious methods for the rearing of infants, but will not adopt new and improved methods.

It is a well-known fact that a large number of infants are still born, or perish from injuries received during birth on account of difficult and protracted labour from pelvic deformities of the mother. However the expectant mother will rarely consult a qualified medical man or woman to find out if her pelvic parts are normal, nor will she get ready necessary garments, etc., for herself and for the coming baby to be used during the puerperal period.

(*b*) **Social Customs.**—Owing to a social custom based on a wrong religious belief especially among illiterate, orthodox Hindoo families a woman in child-birth and puerperium is held to be unclean and defiled ; hence any one touching her during the first fifteen days of her confinement has to take a ceremonial bath to be rendered clean and fit to touch the other inmates of the family. During this period she has to remain confined in a small room, which is not ordinarily used by the other inmates of the house. The room is kept dark with the doors and windows barred with thick and heavy

curtains and every opening stuffed with old rags and papers, as the ignorant people have a notion that fresh air is harmful for both the mother and her child. Very often an *angethi* (open charcoal fire) is kept burning inside the room to further vitiate the air. The poor woman is not given any bath for the first ten days after confinement, nor is she provided with clean clothes during this period. She has to remain in soiled clothes and confined in the vitiated atmosphere during the period when she has a lowered vitality from exhaustion and loss of blood and when she needs the fresh air most.

Even the *dai* or so-called midwife who has a hereditary right to practise midwifery and who usually belongs to a low caste, puts on dirty clothes specially reserved for the occasion, and infected from the previous diseased cases conducted by her. She is uneducated, and has received no training in midwifery except what she has learnt from her mother or mother-in-law. She is very dirty in her habits, and makes vaginal examinations at frequent intervals without washing hands every time even with ordinary water. At the most she will anoint her fingers with dirty oil in the *chiragh* (earthenware oil can) before starting the vaginal examination, and will wipe off the fingers with a dirty rag of cloth, or will rub them on the mud wall or on the floor of the room plastered with cow-dung. The poor woman is made squat on the floor during delivery, and the cord is ligatured with an ordinary piece of thread, and is cut with a dirty, rusty knife or scissors or with a split piece of bamboo, while the cut end of the cord is left to dry and wither away without any appropriate dressings. These dirty habits at the time of child-birth are responsible for a large number of deaths of newly-born infants from tetanus neonatorum or erysipelas and of the mothers from sepsis and puerperal fever. In those cases where deaths do not occur, the mothers suffer from various chronic uterine diseases and lead a miserable life for the remainder of their life owing to want of proper care and attendance at the time of child-birth.

Owing to a superstitious belief among many illiterate communities the mother is not allowed milk or any other nutritious diet for the first four or five days after delivery, but has to subsist only on hot condiments, kernel, etc. With such a low diet in the beginning and a drain of lactation it is no wonder if the poor mother falls an easy prey to tuberculosis or any other infectious disease.

(*c*) **Poverty.**—Owing to poverty a majority of the population especially in industrial towns and cities live in small, insanitary, overcrowded houses, which lower the vitality of both the mother and her baby. The mother does not get sufficient nutritious diet, and has naturally, therefore, not sufficient milk in her breasts to suckle her infant. She cannot afford to purchase it from the *bazaar* and has to feed her infant too early on rice and other ill-suited articles of diet, so that the infant suffers from gastro-intestinal diseases leading to early death.

In winter the poor mother has not sufficient warm clothing to cover her or her baby. She lies on a bed of dry straw or sackcloth, and covers herself and her baby with an old, dirty tattered blanket or quilt. Consequently the poor infant suffers from pulmonary complications from exposure to cold and dies an early death.

In most cases the mother has to work during the day to earn her livelihood, and has, therefore, to neglect her baby who is not given regular feeds or is not properly looked after. Very often the infant has to be drugged with opium, so that it may remain quiet during the day, while the mother is away for work. All these conditions contribute largely to infantile mortality.

3. **Post-Natal Causes.**—Many babies die during the first month of their birth from causes operating during ante-natal and natal periods. But a large number of those which are born healthy of healthy parents and which have survived the first month after birth, succumb to the attacks of zymotic diseases, such as measles, whooping-cough, small-pox, etc.,

before they have completed their first year. These diseases are preventable, and can be prevented by taking necessary precautions, but, owing to ignorance and superstition, there is a notion among the majority of women that these diseases are caused by the wrath of their presiding deities which must be propitiated and which become very angry, if any sort of treatment is adopted.

Prevention of Infant Mortality.—This consists in the organisation of a scheme for maternal and child welfare in municipal towns and cities, and in groups of villages for the rural area. An ideal scheme for a city should be under the supervision of a fully qualified medical woman holding special qualifications in Public Health, and should comprise the following :—

1. A maternity and child welfare centre.
2. Arrangement for training of indigenous *dais*.
3. A maternity home.
4. A milk-depôt.
5. A crêché or day nursery.

1. **Maternity and Child Welfare Centre**.—In each ward of a city there should be a maternity and child welfare centre, to which the following staff should be attached :—

(*a*) Health Visitor.
(*b*) Midwives.
(*c*) Sweeper.
(*d*) Peon.

The maternity and child welfare centre should be located in a suitable house having at least four rooms and a compound with lavatory arrangements. One of these rooms should be used by the medical supervisor or the health visitor as her office, one as a waiting room for mothers and their babies, one for weighing and examining babies and one for exhibiting models and charts showing old and new methods of conducting labour, disadvantages of faulty feeding, insanitary houses, etc. The compound may be used for toddlers and grown up children

to play about, when they accompany their mothers on baby welcome days. If the house is a double-storied one, the upper storey, should be used as residential quarters for the Health visitor and midwives.

(*a*) **Health Visitor.**—There should be at least one health visitor for each centre. She should possess a medical diploma from one of the medical schools in India or should possess a certificate of having received a special training in elementary anatomy, physiology, sick nursing, midwifery and maternity and child welfare work at a recognised school, *e.g.*, at Delhi.

The health visitor should daily visit the houses of the people, especially the poor, find out prospective mothers, and advise them how to keep healthy during pregnancy, and to make necessary preparations for the coming event. She should also talk to the other women of the house on the general principles of hygiene.

The health visitor should ordinarily pay her first visit to a newly-born infant ten days after its birth, when the midwife should usually stop her visits. It is, however, better if she pays one or two visits during the first ten days. At these visits she should advise the mother about bathing and clothing the baby properly, and should suggest the means for improving the baby's physique. She should impress on the mother the necessity of her suckling the baby, but in cases where the mother is unable to do so owing to the attack of syphilis, tuberculosis or any other wasting disease, the health visitor should issue the following instructions for feeding the baby :—

During the six weeks after birth, the infant should be fed every two hours during the day, leaving an interval of four hours at night. If the infant is asleep at the hour for its food, it must be awakened. From the beginning of the second month, the interval between the feeds is gradually increased, until at the end of the second month the infant should be fed every two and a half hours, and after the end of the third

month, every three hours, but it should not be fed at night, unless it happens to be awake.

Cow's milk should be given to infants, but as it differs in its composition from human milk, it is necessary to alter it so as to make it resemble human milk. Thus for a child up to six weeks, one part of cow's milk with two parts of water should be taken, and a teaspoonful of brown sugar should be added to a pint of the mixture. The quantity at one feed to be given should be three or four tablespoonfuls. From six weeks to three months, equal quantities of milk and water should be taken with the same quantity of sugar, but two teaspoonfuls of cream should be added to each feed, which should be about eight ounces. From three months to seven months, one part of water should be added to two parts of milk. The cream to be given at each meal should be the same, but the quantity to be given at each feed should be increased from eight tablespoonfuls to about ten. After seven months it is not necessary to mix water with milk, but cream must be added and a teaspoonful of baked flour or arrowroot may be added to each feed. As the child advances in age, bread, rice and other light foods may be given. The child should be gradually weaned after the ninth or tenth month of its age. If cream is not available, cod-liver oil may be added instead. It is always safe to add boiled water to cow's milk, which should also be boiled. Barley water or lime water may be used with advantage instead of plain water, especially when the child is suffering from diarrhœa, or sodium citrate, two grains to an ounce of milk, may be added in the case of gastro-intestinal troubles.

The feeding-bottle should be boat-shaped with an opening at either end, so that it may easily be cleaned out. It should be fitted at both ends with rubber teats without the intervention of tubes. The bottle should be boiled and rinsed out immediately after use, and should be kept in a solution of soda and water, when not in use. It should be thoroughly rinsed out with cold water before the milk is put into it. The rubber

teats should be turned inside out, and should be well washed out with water. Any milk left in the feeding-bottle after the child has been fed should be thrown way.

James A. Stephen and Edward R. C. Walker[1] suggest a simple method of rendering cow's milk fit for infant feeding by the addition of pharmacopœial lactic acid in the proportion of 1½ drachms to a quart. This gives a concentration of about 0.5 per cent. The acid is stirred into the milk (which must be cold), the last half being added very slowly drop by drop, and thoroughly stirred in to prevent the formation of large curds. As the last drops are added a fine flocculent curd appears. Sugar is added in the proportion of one or two tablespoonfuls of golden syrup (made with canesugar) to a pint. Dextri-maltose may be used for very young or weakly infants, as large amounts of it can be taken without causing diarrhœa. Mellin's food is a comparatively cheap form of dextri-maltose. The advantage is that the milk thus prepared keeps well, and the whole twenty-four hours' supply can be prepared at a time in about fifteen minutes, and put aside to be used as required. Healthy infants fed on this milk thrive well and gain weight steadily and satisfactorily in the manner usually associated with healthy breast-fed infants. It is contraindicated in cases of anhydræmia or circulatory failure.

Skimmed lactic milk prepared from skimmed milk is of value in cases of fat intolerance with large soapy stools and failure to gain weight.

The health visitor should be authorised to issue free woollen garments and blankets to those mothers who are too poor to purchase them during winter. She should also issue tickets for the supply of milk from the milk-depot.

In addition the health visitor should hold baby welcomes at least twice a week at the maternity and child welfare centre, where she should persuade mothers to bring their

1. Lancet, July 9, 1927, p. 63: also *vide* W. M. Marriot and L. T. Davidson, Acidity of the Gastric Contents in Infants, Amer. Journ. of Diseases of Children, 1923, XXVI, p. 542.

infants. Here infants should be regularly weighed under the direct supervision of the medical officer, who would keep a record of their weights. They should be also examined and treated for minor ailments. Their mothers should be advised to go to a neighbouring dispensary for any serious complaint. Children under five years should be given baths and fresh milk to drink, the quantity varying according to age. The health visitor should collect all the women at the centre and give practical demonstrations as well as lantern lectures on general cleanliness and rearing of infants, and on the preventive measures to be adopted on an out-break of infectious diseases, such as measles, small-pox, etc.

(*b*) **Midwives.**—Midwives should possess a diploma in the practice of midwifery and nursing from one of the medical college hospitals. Their number for each centre should vary according to the number of midwifery cases to be attended. Ordinarily there should be one midwife for every 12 to 15 cases. At least one midwife must live on the premises of the welfare centre, if all cannot be accommodated for want of sufficient room.

Midwives should pay house to house visits seeing expectant mothers and explaining to them the advantages of being confined by them and not by the indigenous *dai*. It has been found from experience that in spite of this advice many women prefer to call in their local *dais* at the time of child-birth. Hence there should be an arrangement to give an award of a small sum of eight annas or so to the *dai* who sends for one of the trained midwives employed under the child welfare scheme to be present at the confinement and allows her to conduct the labour.

Midwives should attend cases of normal labour free of charge especially among the poor people, and send for the health visitor or medical officer if any assistance is required. They should continue to visit these cases daily for ten days after delivery, when the health visitor should take them up in

her own hands. Abnormal cases should always be sent to hospital.

An arrangement should be made with the municipal officer of health that his *muharrir* (clerk who registers births and deaths) should send a daily report of births occurring in the ward to the medical officer of the centre who could direct her midwives to visit these cases daily for ten days, even though they have not attended them during child-birth.

The medical officer in charge of the centre must see every case of child-birth occurring in the ward at least once during the first few days, so that she may be able to supervise the work of her health visitor and midwives.

2. **Arrangement for Training of Indigenous Dais.**—It has already been mentioned that untrained indigenous *dais* are one of the chief factors in contributing to the sickness, or in some cases to the deaths of poor mothers and to the prevalent high rate of infant mortality, but owing to poverty, superstition, ignorance and social customs it is unfortunately not possible to abolish altogether this class of *dais*. Hence the next best thing in the present circumstances is to arrange for teaching them the use of improved methods during child-birth. With this view in mind the medical officer and health visitor should hold periodical classes for instructing the *dais* of the ward at the welfare centre by giving demonstrations with the help of model dummies on the correct procedure of conducting labour and the observance of asepsis and cleanliness at the time of child-birth. The *dais* being conservative and averse to new and improved methods would not ordinarily attend these classes, unless they are shown some temptation in the form of a reward of four annas or so for their presence at every class meeting. After a course of about eight lectures they should be examined and granted a certificate of efficiency, if found successful at the test. They should also be supplied with a small midwifery bag containing cottonwool, soap, towel, lysol and other necessary drugs and implements. A record of their work should also be maintained

at the centre, and at the end of the year the *dai* who shows the least number of deaths of the mothers and their infants in her charge may be awarded a cash reward at the local baby show in the presence of other *dais* of the ward.

3. **Maternity Home.**—A well-equipped maternity home with about 20 beds should be provided in each ward near the welfare centre for the accommodation of poor women who cannot arrange for their confinement in their homes, and also for the admission of abnormal and difficult cases of labour which cannot be managed by the midwife or health visitor in the patients' own homes. At the maternity home poor mothers will get skilled attendance at the time of confinement and proper nursing and nutritious diet during the convalescent period, so that they will be able to provide sufficient breast-milk to their babies.

It is essential to establish a pre-natal (pre-maternity) clinic at the maternity home, where a medical woman can examine pregnant women for the presence of pelvic deformities, paying special attention to primiparæ and to women giving a history of a previous difficult and protracted labour. She can also promptly treat pregnant women who show a taint of syphilis and thereby prevent many still-births or premature births. As a routine method the medical woman may examine the urine of all the pregnant women seeking advice at the home, and if she finds any evidence of renal insufficiency or disease, she can at once admit such a woman and take necessary precautions to avoid eclampsia or induce premature labour, if the case is more serious.

There should be a provision for supplying from this home lying-in outfits and baby garments to poor expectant mothers. In this connection it is very essential to enlist the sympathy and help of the indigenous *dais*, who will attend the majority of the women during confinement. If possible they should be encouraged to be present at the ante-natal clinic when pregnant women attend.

4. **Milk-Depôt.**—In each ward there should be a milk-depôt for the supply of pure milk, free or at a cheaper rate, on the production of a certificate, for infants and in some cases for poorly nourished mothers who cannot afford to purchase it from the *bazaar*.

Milk should be purchased from a contractor's dairy, where proper cleanliness should be observed and the milk-cattle should be inspected periodically by the municipal veterinary surgeon. Cow's milk should be used for infant feeding and buffalo's milk or mixed milk for mothers.

Cow's milk after it is received at the depôt should be strained, humanised by the addition of water, cream and sugar and filled in stoppered bottles, each having a capacity of some five ounces and containing a quantity sufficient for one feed only according to the age. The bottles should then be sterilized. The bottles enough for one day's feed should be placed in a basket and handed over to the mother with instructions that the baby should be fed directly from the bottle by removing the stopper and attaching a rubber teat while it is kept in a little hot water.

If it is not possible to arrange for a milk-depôt for the welfare centre, an arrangement should be made with a local milk vendor, who is reputed to keep pure milk that he should supply milk to infants and poor mothers on receipt of an order ticket from the health visitor or medical officer, and should send his account every month to the welfare centre for payment.

5. **Crêchê or Day nursery.**—A crêchê or day nursery should be attached to the welfare centre, where working mothers may leave their babies whilst away from work. The crêchê should be large enough to accommodate at least thirty or forty babies during the absence of their mothers on work, and should be in charge of a trained matron who would look after the babies left there and give them proper feeds at

regular intervals. It would be convenient for bigger children to play if the crêchê is provided with a garden or compound. The only drawback of such a crêchê is the danger of infectious diseases spreading amongst the children, but this can be warded off to a large extent by careful inspection and supervision of the children brought to the crêchê, and by the segregation of those who show the slightest symptoms of ill-health.

The high rate of infant mortality which prevailed in England for many years attracted the attention of many people in the early part of this century with the result that a movement known as "child welfare" was initiated by voluntary contributions in certain advanced districts to provide trained and experienced women visitors to give advice and encouragement to poor mothers of the working class as to the proper methods of rearing their children. This movement led to an appreciable reduction in the rate of infant mortality, wherever it was organised on sound lines.

The successful results achieved by this voluntary movement led the Government of England to amend in 1915 the Notification of Births Act of 1907, by which Sanitary Authorities were empowered to make provision for the care of expectant and nursing mothers and young children.

In 1918 was passed the Maternity and Child Welfare Act, which extended the scheme to children up to five years not attending schools recognised by the Board of Education. This Act also made it compulsory on all Sanitary Authorities to appoint a Maternity and Child Welfare Committee, to which may be co-opted interested persons in order to ensure the co-operation of voluntary organisations. In 1919 the Milk Order was passed which provided for the supply of milk, free and at reduced rates, to necessitous expectant or nursing mothers and to children under five years of age, on the production of a medical certificate. In 1920 the Milk Order was modified to include all cases which were certified medically as

requiring milk on the grounds of health, due regard being paid to the retail price of milk at the time. All these beneficent schemes adopted in England have reduced the average rate of infant mortality to 60 per 1,000, and even to 39 per 1,000 in certain districts.

The state of things in India is quite different. The rate of infantile mortality for large cities in India for 1926 varied from 157 per 1,000 infants born in Bareilly to 733 per 1,000 in Poona City, while it was 287 in Lucknow, 438 in Ahmedabad, 484 in Cawnpore and 510 in Puri. The average for the same year for the whole of the United Provinces of Agra and Oudh was 177.5 per 1,000, for the Punjab 203.43 and 253.38 for the Central Provinces. This appalling high rate of infantile mortality has, however, attracted the attention of Government authorities and philanthropic people during the last decade or so, and the success achieved in the reduction of the great wastage of infant life through effective measures taken in England and other Western countries has induced them to take similar steps in India. This led to the inauguration of the Lady Hardinge and the Lady Chelmsford All-India Leagues of Maternal and Child Welfare. Since 1920 at the instance of Her Excellency the Countess of Reading a National and Baby and Health Week is being organised once a year in almost all the district towns and cities of India in order to arouse public interest in the problem of maternity and child welfare. At these Baby Shows, as they are called, papers are read on various subjects dealing with the causes which operate to increase the infant and maternal mortality and the remedial measures bearing in mind the religious susceptibilities of the people in general. Lantern slides and cinema films are shown to point out the dangers of bad sanitation and the advantages of good sanitation, the improved methods of conducting labour, etc. An exhibition is also held in connection with the Baby Show, where trained nurses and midwives give practical demonstrations about the bathing, clothing and feeding of infants, about general cleanliness, infectious diseases, etc.

Through the efforts of the organising secretaries of these leagues several municipal boards have appointed fully trained and qualified midwives to visit the homes of prospective mothers, to attend to them during child-birth, and to explain to the public in general the measures to be adopted to combat the high infantile mortality prevailing in the localities. In large cities, such as Bombay, Calcutta, Madras, Delhi, Lucknow, etc., the municipalities have, in addition, established maternity and child welfare centres under the management of fully qualified women. The financial asssitance is given in some cases partly by the Government, partly by the municipal boards and partly by the Indian Branch of the Red Cross League of Nations, supplemented sometimes by public charities. But owing to the apathy of the public in general no vigorous campaign has yet been started throughout the length and breadth of the country to combat infantile and maternal mortality, nor have the Provincial Legislative Councils, or the Indian Legislative Assembly taken any practical steps to ameliorate this appalling condition existing in India.

To prevent the havoc wrought by indigenous *dais* it is very essential to pass a Midwives' Act, similar to one passed in 1902 in England, forbidding untrained women to practise as *dais*, forbidding qualified medical men and women to entertain such women during their practice and allowing only qualified and licensed midwives to practise as *dais*. A register of such qualified and licensed midwives should be maintained in every district under the supervision of the Central Midwives' Board. It should also be made compulsory on all municipal and district boards by a legislative act to organise a scheme for the care and protection of expectant and nursing mothers and children up to five years of age. In schools small boys and girls should be taught lessons on the science of elementary hygiene and preventive medicine, and grown up girls of 14 and over should be taught lessons on mother craft and rearing of children. It is also very impera-

tive to organise an intensive educational propaganda to reach the masses by magic lantern demonstrations on subjects relating to health and infectious diseases, but all these efforts are of little avail until elementary education is not spread among the masses and until their financial condition is not improved.

APPENDIX A.

DISINFECTION OF A MUNICIPAL WATER-SUPPLY.

(G. O. No. 100-XI 438 R., dated the 6th May, 1899.)

On the occurrence of an epidemic of typhoid fever or cholera traceable in any way to the water supplied from the municipal water-works, clear water reservoirs and distribution pipes have to be disinfected in the following manner :—

The depth in one compartment of the clear water reservoir should be lowered until only 200,000 gallons of water are left in the reservoir. Ten pounds of permanganate of potash (previously dissolved in buckets or in an iron tank) should then be gradually added at about 6 or 7 o'clock in the evening. At 11 P.M., by which time the demand for drinking purposes will have ceased, the pumps should be started and the pink water slowly pumped through the distribution system. Where there is a raised reservoir this should be emptied by opening some of the scour valves before pumping is commenced, so that the disinfectant may thoroughly wash out the reservoir as well as the pipes.

Arrangements should be made while pumping is in progress, to have all the scour valves opened in rotation, to ensure a proper circulation of the disinfecting fluid.

When the reservoir has been pumped empty the supply from the filters should be turned on, and, as soon as sufficient water has collected, the pumps should be re-started and clear water pumped slowly through the system for half an hour.

By starting pumping at 11 P.M., it should be possible to have the whole operation completed by 3 or 4 o'clock in the morning, before water is required for domestic purposes.

The above procedure is to be observed in the case of an outbreak of typhoid, the only difference in the event of the epidemic being one of cholera is that 10 gallons of commercial hydrochloric acid should be added to the solution of permanganate of potash in the clear water reservoir. The hydrochloric acid should of course be previously diluted in buckets of water before being put in the reservoir.

APPENDIX B.

MODEL BYE-LAWS.

(From the U. P. Municipal Manual, Part III).

I.—PROJECTION BYE-LAWS.

1. Every application for permission to erect or re-erect any projection over a street or drain shall be accompanied by the following plans in duplicate, prepared in the manner prescribed in bye-laws :—

(a) A key-plan of the locality showing the precise situation of the building concerned ;

(b) A plan indicating the situation of the building concerned in relation to the streets or lanes adjoining the building and to the adjoining buildings or land, and indicating the breadth of the adjoining streets or lanes, and in the case of a street or lane of which the breadth is not uniform, the width in the narrowest part ; and

(c) Where an open municipal drain has to be closed, a plan and section, showing clearly how it is proposed to cover the drain in question, and where a culvert is to be built, showing the exact tunnel size of the culvert.

2. The plans shall be drawn to a scale of not less than five feet to the inch. The scale used shall be marked on the plans and the position of the north point shall also be clearly indicated. All plans must be signed by the applicant and show all details necessary to enable the board or the executive officer to judge as to the suitability of the proposed projection. The names of the owners of adjoining buildings or lands, together with the *chuk* and house number shall be given. All projected work shall be indicated by a distinctive colour and a key to any colour used displayed on the plan.

3. The dimensions and position of proposed projections must conform with the conditions hereinafter prescribed.

4. No projection from a ground-floor shall be allowed, except for the purpose of permitting access across a drain to a building.

5. Under every projection over a drain other than a culvert a space of not less than one foot must be left open towards the street.

6. No balcony, verandah, *chhajja* or other projection shall be allowed from an upper storey of a building over a street which has a width of

less than 20 feet at any point in front of the building. In measuring the street the width shall be taken from the edge of the drain nearest to the roadway on the side of the building concerned up to the edge of the drain nearest the roadway on the opposite side.

7. No projection, such as is described in the preceding bye-law, shall exceed 3 feet in width except in the following streets (except over a street exceeding feet in width at every point in front of the building concerned)

8. Projections over public streets or drains may be permitted only on the following conditions :—

(*i*) That the owner or occupier shall daily remove all refuse from the land over which his projection extends and keep the land clean ;

(*ii*) That the owner shall keep any open drain over which the projection extends in good working order and free from depressions in which liquid can stagnate ;

(*iii*) That the owner or occupier shall at any time, on demand, vacate the surface of his projection, for a period of not more than six hours to permit of municipal servants inspecting or repairing or cleaning any covered drain therein ;

(*iv*) That the owner shall duly pay in advance the fees prescribed by the next following bye-law.

9. Subject to bye-law 10, the annual fees for projections shall be as shown in the accompanying schedule.

10. When two or more projections from the same storey cover the same ground the highest fees chargeable for any one of such projections shall be levied and no other.

11. Nothing in these bye-laws shall be construed to derogate from the power conferred on the board by Section 211 of the Act to remove encroachments and projections over streets and drains, notwithstanding that such encroachments and projections may have been sanctioned.

II.—BUILDING BYE-LAWS.

1. The board hereby requires, with reference to Sub-section (2) of Section 178, that notice be given in the case of all buildings wheresoever situated within municipal limits.

2. Every notice of intention to erect, re-erect or make a material alteration in a building or to make or enlarge a well shall be accompanied by plans in duplicate, as prescribed in the following bye-law. Each such notice shall also be accompanied by a key-plan, showing the precise situation of the building.

3. The plans shall be drawn to a scale of not less than 5 feet to the inch. The scale used shall be marked on the plans ; and the position

of the north point relative to the site plan of the house shall also be clearly indicated. All plans must be signed by the applicant. They must show all details necessary to enable the board to judge as to the suitability of the proposed building. In particular, the following matters must be clearly shown on the plans :—

(*a*) The situation of the proposed building, relative to the streets or lanes adjoining it and to the adjoining houses or other properties, the names of the owners of the adjoining houses or other properties together with the *chuk* and house number should always be given. The breadth of the adjoining streets or lanes must be shown. In case the breadth is not uniform the narrowest width should also be shown.

(*b*) Gutters and down spouts should be clearly marked on the plans.

(*c*) The position of, and full details regarding all wells, drains, latrines, *sandases* and other sanitary conveniences, should be clearly given.

(*d*) When sanction is required in respect of a well, the internal diameter and the distance from the nearest privy should be shown, and it should be clearly stated whether the suggested work is compatible with the conditions laid down in the bye-laws.

(*e*) Each application in respect of a building should be accompanied by plans showing *inter alia* the following :—

(*i*) The ground floor and the position of the building relative to adjoining streets, properties and unoccupied spaces.

(*ii*) The first or upper floor and each additional floor.

(*iii*) The addition of the building on the main frontage line.

(*iv*) At least one cross-section of the building.

All plans must be duly dimensioned. The height of the plinth must be stated in all cases. The dimensions of all walls and doors as also the height of the rooms, windows, or other openings must be given. All new work should be indicated on the plan by a distinctive colour; and a key to the colours used should be given on the plans. It should be stated whether the house is to be *pucca* or *kutcha* and of what material the outer covering of the roof will be made.

4. No mosque, temple, church or other sacred building shall be erected or re-erected unless the frontage is at least 15 feet from the centre of the road on which it abuts.

5. All houses intended for human habitation must be *pucca* or *kutcha-pucca*, except in the following areas :—

6. Except in the areas mentioned in bye-law 5 above, the outer covering of all roofs must be made of tiles, iron sheets or other non-inflammable materials.

7. Every person who erects or re-erects a building which is within 100 feet of the sewer and the water-main shall link the privies in such building with the sewer.

8. Every person who erects or re-erects a building the whole or any part of which is intended or used for human habitation shall, if so required, construct one or more privies in connection with or as part of such building.

9. All persons who erect or re-erect buildings must conform to the standard types of privies prescribed by the board for (*a*) privies connected with the sewer, (*b*) servants' latrines for bungalows in civil lines and *ahatas* in the city, (*c*) privies on ground-floors, and (*d*) privies on first and higher floors.

Sanction will not be given unless these plans and all the conditions imposed in respect thereof are adhered to; when any deviation from these plans or conditions is proposed, the health officer will be consulted by the Public Works Committee before a decision is given.

10. The Public Works Committee will fix in each case the precise position of the privy or privies inside the house or compound.

11. All privies connected with the sewer must be properly tapped and the plumbing and pipe work must conform to the specifications prescribed by the drainage bye-laws.

12. All privies connected with the sewer must be separated from any room used or intended to be used for human habitation by a masonry wall. Approach to a privy shall be through a tightly fitting door.

13. Every privy shall have a window opening directly upon the external air and of at least 4 square feet superficial area. This window shall be situated immediately under the platform of the privy. Sufficient ventilation shall also be provided to carry gases from the privy into the open air. In this bye-law "window" shall mean an opening protected by wire netting or by iron bars not closer than one inch to each other.

14. The platform of every privy shall be of non-absorbent material, such as glazed earthenware or smooth Portland cement not less than half an inch thick, so that no urine can penetrate. The whole privy shall, as regards both internal and external walls, be constructed of *pucca* masonry in lime.

15. The floor of a privy must be made of one or other of the following materials, to be selected by the owner: glazed tiles, stone cement or thoroughly well-burnt bricks plastered with cement not less than one-fourth inch thick. The floor must be in every part of a height of not less than nine inches above the level of the surface of the ground adjoining the privy and must be sloped in all sides of the drain.

16. The house drains through which waste or sullage water is likely to pass must be made of half-round or whole earthenware glazed pipes not less than six inches in diameter properly laid upon a bed of concrete not less than four inches thick, where a house is connected with the sewer. In other cases the drain must be a *pucca* masonry cemented drain and all joints must be rendered tight with cement. These latter drains must be connected with the roadside drain, where a roadside drain exists within 100 feet of the premises.

17. The house shall be provided with iron gutters and down spouts to take all the rain-water which falls on its roof, *chhajjas* or other projections. The gutters and down spouts shall be securely fixed and the latter shall discharge into the surface drains by an elbow piece, the orifice being not more than one foot above the level of the bed of the drain and discharging in the direction of the flow of the drain.

18. Every room intended for or used for human habitation must have at least two ventilating openings of a superficial area of not less than 12 square feet each.

19. When a house is used for dwelling purposes not more than two-thirds of the total area of the site shall be built over. In the case of properties where there are shops below and houses above, this bye-law shall not apply to the storey occupied by the shops, but shall apply to all other storeys.

20. The lowest point of the plinth shall be at least 1½ feet above the highest point of the road opposite the house.

21. No rooms intended for or used for human habitation shall have a height of less than 10 feet.

22. (1) The term storey shall be held to mean a room or set of rooms in a building the floors of which are at or near the same level.

(2) The height of a building shall be held to mean—

(*a*) in the case of pent-roofs the greatest height to top of walls (excluding gable walls) above the level of the centre of the street on which the building abuts,

(*b*) in the case of flat-roofs, the height to the top of the parapet above the level of the centre of the street,

(3) No three-storeyed house, or any part thereof, abutting on any street shall exceed in height one and a half times the width of the street:

Provided that, if a building, or one or more of its storeys, be set back from the edge of the street, the height of such building or portion that is set back may be increased beyond the height otherwise required by this bye-law by double the distance that it is set back.

(4) The number of storeys shall not in any case exceed four and the aggregate height shall not exceed 60 feet, except with the special permission of the Public Works Committee.

(5) If a building abuts on two or more streets of different width, the building shall be deemed, for the purpose of this bye-law, to abut on the street that has the greatest width.

23. No wells shall be sanctioned, except and unless they are *pucca* throughout. If built inside a house, the internal diameter must be at least 3 feet. No well shall be sanctioned within 15 feet of a privy unconnected with the sewer.

III.—BYE-LAWS FOR THE REGULATION AND INSPECTION OF SLAUGHTER-HOUSES.

INSPECTION OF ANIMALS FOR SLAUGHTER.

1. No animal shall be slaughtered in any slaughter-house unless it has been inspected and passed by the inspecting officer appointed in this behalf.

2. The board shall give public notice of the time and place whereat inspections of cattle intended for slaughter in the municipal slaughter-house are held.

3. At the time and place so appointed, the inspecting officer shall examine every animal produced before him, and satisfy himself that the animal—

(*i*) is fit for use as human food,

(*ii*) is not diseased or advanced in pregnancy,

(*iii*) is not very infirm or excessively old:

Provided that an animal which has met with an accident, rendering it unfit for further work, shall not be rejected merely on this account.

4. If the inspecting officer is satisfied as above, and not otherwise, he shall fill up, or cause to be filled up under his signature, columns 1 to 6 of a pass with its counterfoil in form A appended to these bye-laws and give it to the person producing the animal for inspection. The animal shall then, in the presence of the inspecting officer, be marked on the head, hair or skin with a municipal seal or branded with a municipal brand, as the board may prescribe.

5 Any animal produced for inspection which is affected by any contagious disease, or which may reasonably be suspected of being so affected shall, if the inspecting officer so directs, be forthwith seized and removed to the cattle infirmary for treatment at the expense of the owner; or the animal may be disposed of in accordance with Section 244 of the Act.

6. Any animal produced for inspection, which is in a dying condition, but not so affected as to be dealt with under the preceding bye-law, shall, if the inspecting officer so directs, be forthwith seized and disposed of in such manner as the inspecting officer may direct:

Provided that this bye-law shall not apply to an animal which has met with an accident.

OFFICER-IN-CHARGE OF SLAUGHTER-HOUSE.

7. A municipal officer shall be on duty at the slaughter-house throughout the hours prescribed for slaughter and such officer shall be deemed to be the officer-in-charge of the slaughter-house.

8. The officer-in-charge shall keep up a daily register showing the number and description of animals slaughtered at the slaughter-house; and shall send a monthly abstract of this register to the municipal office.

SLAUGHTER-HOUSE FEES.

9. Every butcher using the slaughter-house shall pay fees at the following rates, which shall be posted up at the door of the slaughter-house:—

For each animal slaughtered.

	Annas.	Per head.
Bullocks		
Buffaloes		
Goat, sheep, kids and lambs		
Horned cattle		
Other animals		

10. Unless the collection of fees is farmed every person from whom any such fees are leviable shall pay them to the officer-in-charge.

11. On receipt of the fee the officer-in-charge shall fill up a ticket and counterfoil in the form B attached to these bye-laws, and hand the former with the coupon attached to the person who paid the fee. The progressive total of the daily receipts shall be entered in the place provided at the foot of each counterfoil as each ticket is issued.

12. The holder of a ticket shall produce the ticket when called upon to do so by the executive officer (secretary or any other officer of the

board duly authorized in this behalf). Such officer shall, after such examination as he may think necessary, fill up the counterfoil and shall return the ticket to the holder after initialling it.

AT THE SLAUGHTER-HOUSE.

13. No animal shall be admitted, and no person shall bring any animal, into the slaughter-house, unless it is covered by a pass in form A, as prescribed in bye-law 4 above, and unless the fee prescribed in bye-law 9 has been paid. The pass must be presented at the slaughter-house within 3 days of the time of issue.

14. The officer-in-charge shall receive the pass and if it is in order and the fee prescribed in bye-law 9 above has been paid, he shall allow the animal or animals covered thereby admission into the slaughter-house, filling up columns 7 to 9 of the pass. The passes shall be dealt with in such manner as the board may direct.

15. Except with the general or special permission of the board no one but the butchers, their assistants, and the municipal officers connected with the slaughter-house, shall enter or be allowed to enter the premises during the process of slaughtering, skinning or cutting up the carcases.

16. No person affected with leprosy, or with any skin disease, shall enter, or be allowed to enter, the slaughter-house premises.

17. No dogs shall be admitted into, or be allowed to enter, the slaughter-house. All dogs found there shall be destroyed.

18. No animal shall be admitted and no person shall bring any animal, into the precincts of the slaughter-house, unless it is intended for immediate slaughter. All cattle awaiting slaughter shall be kept in pens attached to the slaughter-house, and there properly secured with ropes until required for slaughtering.

19. Butchers shall make their own arrangements for the feed of their cattle while in the pens, and shall have their own servants to look after them.

WITHIN THE SLAUGHTER-HOUSE.

20. No person shall slaughter any animal except at such hours as may from time to time be fixed by the board. These hours shall be notified in some conspicuous place in the slaughter-house.

21. Each butcher shall have a place assigned to him for slaughtering by the officer-in-charge, and he shall slaughter his cattle immediately over the central drain so as to prevent the blood of the animal from flowing upon the floor.

22. Immediately after the slaughter of an animal the butcher shall cause the portion of the slaughter-house assigned to him to be carefully washed and cleaned.

23. Every carcase shall, after slaughtering, skinning and cleaning, be presented for the inspection of the officer-in-charge of the slaughter-house, and no butcher shall remove from the slaughter-house, except in accordance with the next clause of this bye-law, any carcase which appears to the officer-in-charge to show signs of any contagious disease, or other disease rendering the meat unfit for human consumption.

If any such carcase be found, it shall be disposed of in accordance with the provision of Section 244 of the Act. In the event of a dispute arising under this bye-law the matter shall be referred to the health officer of the board whose decision shall be final.

24. If, on the inspection prescribed by the preceding bye-law, the carcase is found to be fit for human consumption, each piece of meat cut therefrom shall have impressed thereon or affixed thereto, under the supervision of the officer-in-charge, such stamp or seal as the board may from time to time prescribe.

25. The skin of an animal whose carcase has been condemned under bye-law 23 above shall, if the officer-in-charge or the health officer so direct, be disposed of in the same manner as the carcase.

26. Skins, entrails, and offal shall be removed from the slaughter-house by the butchers, and any skin, entrails or offal not removed before the time at which the slaughter-house is closed for the day shall become the property of the board, and may be disposed of in such manner as seems to it fit :

Provided that, if the board so prefers, it may delegate to the officer-in-charge the power to have such skins, entrails or offal removed at the owner's or butcher's expense ; and the officer-in-charge may refuse such butcher or owner or his servant, any subsequent admission to the slaughter-house until such expense is made good to the board.

27. No person shall remove any skins, entrails and offal from the slaughter-house until they have been properly washed and cleaned.

28. The solid contents of the entrails shall not be washed into the cesspools, but shall be cleaned up and removed by the butchers or their assistants at the same time as the entrails and offal are removed under bye-law 26 above.

29. Meat, entrails and offal shall be removed from the slaughter-house in covered carts or covered buckets or vessels, of a pattern to be approved by the board, and the officer-in-charge of the slaughter-house shall daily inspect the said carts, baskets or vessels, and see that they are kept clean and in good order.

30. No person shall employ the process of insufflation (the blowing of carcases) in the slaughter-house.

31. No butcher or other person shall sell, or allow to be sold, meat on, or at the slaughter-house premises.

32. Butchers or private individuals using the slaughter-house shall be responsible for any damage wilfully or negligently caused to the slaughter-house either by their own act or the acts of their servants and any butcher and private person using the slaughter-house who refuses to pay such damage shall be excluded from the slaughter-house until he pays the cost of damage done.

33. No butcher or other person shall remove, deface or alter any seal or brand impressed in accordance with bye-law 4 above, or any stamp or seal impressed upon or affixed to any piece of meat in accordance with bye-law 24 above.

PENALTY.

In exercise of the power conferred by Section 299 (1) of the Act, the board hereby directs that a breach of any of the provisions of bye-laws 9, 10, 12, 13, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31 and 33 shall be punishable with fine which may extend to Rs. 50, and, when the breach is a continuing breach, with a further fine which may extend to Rs. 5 for every day after the date of the first conviction during which the offender is proved to have persisted in the offence.

IV.—BYE-LAWS REGULATING THE SALE OF MEAT.

1. In these bye-laws "meat" means the flesh of horned cattle, goats, swine, or sheep intended for human or animal consumption.

2. No person shall sell or expose for sale any meat within the limits of the municipality unless he has been granted a license in this behalf.

3. The executive officer or Secretary shall be the licensing officer for the purposes of these bye-laws.

4. A license granted under these bye-laws shall be subject to the following conditions:—

(1) No one shall sell or expose for sale the flesh of any animal which has died from a natural cause, or any meat which has been blown up or artificially stuffed.

(2) No one shall place any meat intended for sale in or on a dirty basket or board or expose such meat without covering it with a clean cloth.

(3) The shop for the sale of meat shall have chicks hung up on all the open sides, so that the meat kept for sale may not be seen by the passers-by, and shall be free from flies.

(4) The floor of the shop must be paved with bricks plastered all over, and it must be thoroughly washed every day before the shop is closed.

(5) The shop itself must be whitewashed once a month.

(6) The licensee shall not sell meat at any place other than that mentioned in the license.

A breach of any of these conditions shall involve forfeiture of the license.

5. On receipt of an application for a license, the licensing officer shall either grant the license or, for reasons to be recorded, may refuse to grant it.

6. The licensing officer may cancel or suspend a license for breach of any of the conditions specified in bye-law 4.

7. An appeal shall lie to the board (or *Chairman* or *Health Committee*) from an order of the licensing officer refusing or cancelling or suspending a license : provided that the appeal is made within 10 days of the date of the receipt of the order.

8. No one shall carry meat through any street or public place except in a clean receptacle and covered with a clean cloth.

PENALTY.

In exercise of the power conferred by Section 299 (1) of the Act, the board directs that any breach of the provisions of bye-law 2 or 8 shall be punishable with fine which may extend to fifty rupees, and when the breach is a continuing breach, with a further fine which may extend to five rupees for every day after the date of the first conviction during which the offender is proved to have persisted in the offence.

Note.—If a board desires to charge a fee for such license it must make a bye-law for the purpose.

V.—DAIRY BYELAWS.

PART I.

The manner in which cattle-sheds and cow-houses are to be constructed and connected with the municipal drains.

1. Every cattle-shed and cow-house must be well paved with asphalt, stone, brick-on-edge with cement pointing, or flagstones set in cement, or with some other suitable impervious material approved by the Chairman or the executive officer.

2. (1) The floor of every cattle-shed and cow-house must incline to a channel or gutter, sloping towards and draining directly into a gully pit communicating with a sewer situated immediately outside the shed or house.

Provided that, in the unsewered area :—

(a) such channel or gutter must drain directly into a cesspool similarly situated, the contents whereof shall be removable, and

(b) such cesspool must be constructed of bricks set in cement and cement plastered, or of some other suitable impervious material approved by the Chairman or executive officer and must be so constructed as not to admit rain-water.

(2) The slope of the floor must be made so as to incline away from the heads of animals, and, in the case of floors of sheds or houses hereafter constructed and accommodating two rows of animals, must be made so as to incline outwards.

3. Every cattle-shed and cow-house in which cattle are kept for sale or for the sale of their produce must have, for purposes of light and ventilation, an opening of not less than one foot in width, on all sides below the junction of the eaves and the wall of the building.

4. Every cattle-shed and cow-house must have one storey only, and there shall be no construction, arrangement or fixture permitting of any lifts or sleeping places, either over the roof or within the interior over the stalls :

Provided that—

(a) the Chairman or executive officer may sanction the erection of the upper storey, if the floor thereof be constructed of impervious material to his satisfaction ; and

(b) an appeal shall lie to the health committee in any case in which the Chairman or executive officer refuses such sanction.

5. The interior fittings of every cattle-shed and cow-house must be so constructed and placed as to provide for each animal kept in the shed or house a clear superficial floor space of at least 40 square feet and a clear lateral space of at least 5 feet.

6. The walls of every cattle-shed or cow-house must be at least seven feet in height from the level of the floor up to the junction of the eaves with the walls.

7. (1) No cattle-shed or cow-house in which cattle are kept for sale or for the sale of their produce shall be so constructed as to provide for the storage of milk or milk vessels therein.

(2) For every cattle-shed or cow-house where milch cows or milch buffaloes are kept there shall be provided a separate shed or place for the temporary storage of milk and milk vessels,

(3) Such shed or place shall not communicate directly with any cattle-shed or cow-house, and shall not, without the special permission of the Chairman or executive officer, be placed within a distance of fifteen feet from any privy connected with a sewer or 25 feet from any service privy or urinal.

PART II.

Inspection of milch cattle and cleansing, drainage, and water-supply of dairies and cattle-sheds in the occupation of persons following the trade of dairymen or milk sellers.

8. In this part—

(*a*) **Cattle-shed** means any place in which milch cattle are kept, and

(*b*) **Dairyman** means any person following the trade of cow keeper, milk supplier or milk seller.

9. Every occupier of a cattle-shed, every person having the care or control of milch cattle, and every dairyman shall afford all reasonable assistance and facility to the executive officer, health officer, the sanitary inspector, and any other servant of the board appointed to inspect milch cattle, whenever he is so required by any such servant desiring to inspect such cattle.

10. Every dairyman—

(*a*) shall cause every part of the interior of every cattle-shed in his occupation to be thoroughly cleansed from time to time and as often as may be necessary to secure cleanliness, and

(*b*) shall cause the floor of every such shed to be thoroughly swept, and all dung and other offensive matter to be removed, at least twice every day, and

(*c*) shall, after the floor is so swept, cause it to be swilled with fresh water.

11. Every dairyman shall cause the drainage of every cattle-shed in his occupation to be so arranged that all liquid matter which falls or is cast upon the floor shall be drained off by suitable means to be approved by the Chairman or executive officer.

12. Every cattle-shed in which milch cattle are kept for the sale of their produce, and which is within a radius of 600 feet from a municipal standpost, must be provided with an adequate supply of filtered water to the satisfaction of the Chairman or executive officer—

(*a*) for the cattle to drink,

(*b*) for washing utensils used for milk, and

(*c*) for flushing purposes.

No unfiltered water shall be supplied to any such cattle-shed.

PART III.

Cleanliness of milk stores, milk shops and milk vessels.

13. In this part—

Dairyman means any person following the trade of cow keeper, milk supplier or milk seller.

14. Every dairyman who is in occupation of a milk store or milk shop shall cause every part of the interior of such store or shop to be thoroughly cleansed from time to time, and as frequently as may be necessary to maintain the store or shop in a thorough state of cleanliness.

15. Every dairyman shall—

(*a*) cause every vessel used by him for containing milk to be thoroughly cleansed with steam or boiling water immediately after such use ; and

(*b*) take all proper precautions for maintaining every such vessel in a constant state of cleanliness.

PART IV.

Procedure on the occurrence of contagious disease.

16. In this part—

(*a*) **dairy** includes any farm, farm-house, cattle-shed, cow-house, milk stall, milk shop or other place from which milk is supplied, or in which milk is kept for the purpose of sale, and

(*b*) **dairyman** includes any owner or occupier of a dairy, as defined in clause (*a*) of this bye-law, and any person following the trade of dairyman, milk supplier or milk seller.

17. Every dairyman shall, whenever any milch animal in his dairy is affected with any contagious disease, forthwith give notice to the health officer.

18. Every dairyman shall, in order to prevent infection or contamination, forthwith remove or cause to be removed from his dairy and from the proximity of other animals any animal therein which is found to be suffering from any contagious or infectious disease.

19. On the outbreak of any contagious or infectious disease every dairyman shall if so required by notice from the health officer—

(*a*) cause his dairy to be temporarily emptied of all animals, and

(*b*) cause the whole interior surface of the dairy to be disinfected or limewashed, or both.

20. No dairyman shall at any time permit any person suffering from any dangerous disease to enter or remain in his dairy or the precincts thereof.

21. No dairyman shall sell or permit to be sold the milk of any animal suffering from any contagious or infectious disease (including tubercular disease of the udder), or shall add such milk, or permit it to be added, to any milk of other animals which is intended for sale or for human consumption.

22. No dairyman shall deposit or keep any milk which is intended for sale—

(*a*) in any room or place where it would be liable to become infected or contaminated by impure air, or by any offensive, noxious or deleterious gas or substance, or, by any noxious or injurious emanation, exhalation or effluvium, or

(*b*) in any room used as a kitchen or inhabited room, or

(*c*) in any room or part of a building which is used for sleeping, or

(*d*) in any room, place or part of a building in which there is any person suffering from any dangerous disease, or

(*e*) in any room, place or part of a building which has been used by any person suffering from any dangerous disease, unless it has been thoroughly disinfected to the satisfaction of the health officer, or

(*f*) in any room or part of a building in which there is any urinal or privy or any direct inlet to any drain, or

(*g*) otherwise than in covered receptacles.

23. No dairyman shall cause or permit any cow belonging to him or under his care or control to be milked for the purpose of obtaining milk for sale or for human consumption—

(*a*) unless at the time of milking the udder and teats of such cow are thoroughly clean, and

(*b*) unless the hands of the person milking such cow are thoroughly clean and free from all infection or contamination.

24. No person shall—

(*a*) carry any milk for sale or for human consumption in any vessel unless such vessel be made of some impervious material and be provided with a suitable covering, or

(*b*) allow any milk while being so carried to be exposed to dirt, dust or any other offensive matter.

PART V.

25. If any person commits a breach of any of the foregoing bye-laws, the Chairman or executive officer may, in his discretion, send him written notice to discontinue such breach.

PART VI.
PENALTY.

In exercise of the power conferred by Section 299 (1) of the Act, the board hereby directs that every breach of any of the foregoing bye-laws shall be punishable with fine which may extend to twenty rupees, and, in the case of continuing breach, with a fine which may extend to five rupees for every day during which the breach continues after the date of the first conviction.

VI.—BYE-LAWS FOR CONTROLLING THE MANUFACTURE AND SALE OF AERATED WATER.

Note.—*These bye-laws may be applied* mutatis mutandis *to ice factories.*

1. No person shall establish the business of an ærated water factory within 100 feet of any cow-house, stable, public latrine, cesspit or public dust-bin.

2. Every owner or occupier of an ærated water factory shall comply with the following conditions :—

(*a*) He shall not maintain a privy on the premises unless it is separated from the factory by an open passage at least 6 feet wide and is situated more than 20 feet from the factory windows and has no direct communication with the factory.

(*b*) He shall not cause or suffer any room adjacent to the factory to be used as a living or sleeping-room unless it is separated from the factory by a substantial wall, and unless it contains a window opening directly into a passage or space open to the sky not less than 8 feet wide.

(*c*) He shall cause any drains, pipes or sewers for carrying off sullage and sewage matter which run under the factory to be constructed to the satisfaction of the health officer.

(*d*) Where drains communicating with municipal drains cannot be constructed he shall cause a separate receptacle to be kept for the reception of all foul water, and the contents thereof to be removed daily to such place as the health officer may direct.

(*e*) He shall provide that the premises shall have a window or windows with an area for the passage of light of at least one-tenth of the floor area of each room, and that each window shall be capable of being opened and shall be covered by wire gauze of such a mesh as will keep out flies, and (if considered necessary by the health officer) he shall provide for the premises self-closing doors partly of wood

and partly of gauze netting of a similar mesh to that covering the windows.

(*f*) He shall cause the floors, drains and the walls, to a height of 6 feet, to have a smooth, non-absorbent surface.

(*g*) He shall cause the water used in the manufacture of ærated water to be drawn from the municipal filtered supply or, if such a supply is not available, from a well of a type approved by the health officer.

(*h*) When a filtered water-supply is available he shall provide a stand-pipe and tap within the factory.

(*i*) He shall provide within the factory three tanks or receptacles—

(1) One a special covered cistern to contain water to be used in æration, which he shall connect directly to the supply tap or pump, and shall so locate as to be free from sources of contamination, but to admit of being readily cleansed ;

(2) One for washing and disinfecting the bottles and brushes ; and

(3) One for finally washing out bottles before re-filling.

(*j*) He shall cause the premises to be open to the inspection of the chairman, executive officer, health officer or any other member or officer duly authorized in this behalf.

(*k*) He shall not himself dwell or sleep, or suffer any other person to dwell or sleep in the factory.

(*l*) He shall not suffer any animal to be kept in the factory.

(*m*) He shall not suffer any *hookah* or other appliance for smoking or any bedding or soiled clothes, or other articles not required for the purposes of the factory, to be kept in the factory.

(*n*) He shall cause the utmost cleanliness to be observed in the various processes of manufacture, and the premises and appliances to be kept in a thoroughly clean and sanitary condition.

(*o*) He shall cause all the inside walls, about the height of six feet, and all the ceilings or roofs of the factory, whether plastered or not, and all passages to be limewashed at least once in every three months.

(*p*) He shall not use or suffer to be used in the manufacture of ærated water sugar, acid and essence of flavouring agents which are not of good quality.

(*q*) He shall not allow water used in the factory to be carried in *massaks* or otherwise than in metal vessels.

(*r*) He shall cause all bottles to be filled direct from the tap in the storage water cistern and shall not suffer any dippers to be used for filiing the bottles.

(*s*) He shall cause the brushes used for scrubbing the interior of dirty bottles and the bottles themselves to be cleaned in a solution of permanganate of potash of the strength of five grains to a gallon of water and shall cause the bottles after the preliminary soaking and cleaning in one tank to be finally washed out in or from a second tank, which shall contain a tap water solution of permanganate of the strength of half a grain to the gallon. When the premanganate in the second tank has turned brown, he shall cause it to be renewed.

(*t*) He shall cause the three tanks to be well cleaned and rinsed out once a week with permanganated water of the strength of half a grain to a gallon.

(*u*) He shall not suffer any rubber rings to be used in the bottles unless they are in good order and shall cause any ring which has deteriorated to be destroyed.

(*v*) He shall cause labels bearing the address of the factory and the name of the owner or manager to be affixed to each bottle.

(*w*) He shall not employ on the premises a person suffering from any contagious or infectious disease.

PENALTY.

In exercise of the power conferred by Section 299 (1) of the Act, the board directs that any breach of any of the provisions of the above bye-laws shall be punishable with fine, which may extend to Rs. 100, and when the breach is a continuing breach, with a further fine which may extend to Rs. 5 for every day after the date of the first conviction during which the offender is proved to have persisted in the offence.

VII.—BYE-LAWS FOR THE REGULATION AND CONTROL OF BAKERIES.

1. **Bakery** means a building in which European confectionery is prepared for sale. Confectionery includes all sorts of bread, biscuits, sweetmeats or the like.

2. No person shall establish a bakery or cause a bakery to be established within 100 feet of any cow-house, stable, public latrine, open sewage, cesspit or public dust-bin.

3. Every owner or occupier of a bakery shall comply with the following conditions :—

(*a*) He shall not maintain a privy on the premises, unless it is separated from the bakery by an open passage at least six feet wide and is situated more than 20 feet from the bakery window and has no direct communication with the bakery.

(*b*) He shall cause any drains or drain pipes or sewers for carrying off sullage or sewage matter which run under or near the bakery to be constructed to the satisfaction of the health officer.

(*c*) He shall not cause or suffer any room adjacent to the bakery to be used as a living or sleeping room, unless it be separated from the bakery by a substantial wall, and unless it contains a window opening directly on a passage or space open to the sky not less than eight feet wide.

(*d*) He shall provide the bakery with a window or windows with an aperture for the passage of light of one-tenth of the floor area and capable of being opened, and shall cover the windows with wire gauze of such a mesh as will keep out flies and (if considered necessary by the health officer) shall cause the bakery to have self-closing doors, with panels partly wood and partly filled in with galvanized gauze netting.

(*e*) He shall cause a good impermeable floor to be provided over the whole area of the bakery.

(*f*) He shall cause the kneading tables or troughs, if not of masonry, to be covered with galvanized iron or zinc sheeting or tin or other impermeable material.

(*g*) He shall cause the bakery to be open to the inspection of the chairman, executive officer, health officer or any other member or officer duly authorized in that behalf.

(*h*) He shall not himself dwell or sleep or suffer any other person to dwell or sleep in the bakery.

(*i*) He shall not suffer any animal to be kept in the bakery.

(*j*) He shall not suffer any *hookah* or other appliance for smoking, or any bedding or soiled clothes, or other articles not required for purposes of the bakery, to be kept in the bakery.

(*k*) He shall cause kneading tables, troughs, and all utensils used in the bakery to be thoroughly scrubbed and washed with water daily.

(*l*) He shall not use or suffer to be used in the preparation of confectionery any unwholesome materials.

(*m*) He shall cause all dough and other materials used in preparing the products of the bakery and all products of the bakery to be kept in clean receptacles and to be cleanly covered to the satisfaction of the health officer.

(*n*) He shall cause all the inside walls and the ceiling of the bakery, whether plastered or not, and all passages to be limewashed at least once in every three months.

(*o*) He shall not cause or suffer any person other than employés or a member or official of the board to enter the bakery.

(*p*) He shall not employ in the bakery any person suffering from any contagious or infectious disease or allow any such person to sell confectionery in his behalf.

(*q*) He shall not carry or cause to be carried confectionery for sale or delivery to a customer except in tins or other suitable metal boxes provided with properly fitted covers.

PENALTY.

In exercise of the power conferred by Section 299 (1) of the Act, the board directs that any breach of bye-laws 2 and 3 shall be punishable with fine which may extend to Rs. 100, and when the breach is a continuing breach, with a further fine which may extend to Rs. 5 for every day after the date of the first conviction during which the offender is proved to have persisted in the offence.

APPENDIX C.

Sections of the Indian Penal Code for Offences affecting the Public Health, Safety, etc.

S. 268. *Public Nuisance.*—A person is guilty of a public nuisance who does any act or is guilty of an illegal omission which causes any common injury, danger, or annoyance to the public or to the people in general, who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right

A common nuisance is not excused on the ground that it causes some convenience or advantage.

S. 269. *Negligent act likely to spread infection of disease dangerous to life.*—Whoever unlawfully or negligently does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine, or with both.

S. 270. *Malignant act likely to spread infection of disease dangerous to life.*—Whoever malignantly does any act which is, and which he knows and has reason to believe to be, likely to spread the infection of any disease dangerous to life, shall be punished with imprisonment of either description for a term which may extend to two years, or with fine, or with both.

S. 271. *Disobedience to quarantine rule.*—Whoever knowingly disobeys any rule made and promulgated by the Government of India, or by any Government, for putting any vessel into a state of quarantine, or for regulating the intercourse of vessels in a state of quarantine with the shore or with other vessels, or for regulating the intercourse between places where an infectious disease prevails and other places, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine, or with both.

S. 272. *Adulteration of food or drink intended for sale.*—Whoever adulterates any article of food or drink, so as to make such article noxious as food or drink, intending to sell such articles as food or drink, or knowing it to be likely that the same will be sold as food or drink, shall be punished with imprisonment of either description for a term which

may extend to six months, or with fine, which may extend to one thousand rupees, or with both.

S. 273. *Sale of noxious food or drink.*—Whoever sells, or offers or exposes for sale, as food or drink, any article which has been rendered or has become noxious, or is in a state unfit for food or drink, knowing or having reason to believe that the same is noxious as food or drink, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 274. *Adulteration of drugs.*—Whoever adulterates any drug or medical preparation in such a manner as to lessen the efficacy, or change the operation of such drug or medical preparation, or to make it noxious, intending that it shall be sold or used for, or knowing it to be likely that it will be sold or used for, any medicinal purpose, as if it had not undergone such adulteration, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 275. *Sale of adulterated drugs.*—Whoever knowing any drug or medical preparation to have been adulterated in such a manner as to lessen its efficacy, to change its operation, or to render it noxious, sells the same or offers or exposes it for sale, or issues it from any dispensary for medicinal purposes as unadulterated, or causes it to be used for medicinal purposes by any person not knowing of the adulteration shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 276. *Sale of drug as a different drug or preparation.*—Whoever knowingly sells, or offers or exposes for sale, or issues from a dispensary for medicinal purposes any drug or medical preparation, as a different drug or medical preparation, shall be punished with imprisonment of either description which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 277. *Fouling water of public spring or reservoir.*—Whoever voluntarily corrupts or fouls the water of any public spring or reservoir, so as to render it less fit for the purpose for which it is ordinarily used, shall be punished with imprisonment of either description for a term which may extend to three months, or with fine which may extend to five hundred rupees, or with both.

S. 278. *Making atmosphere noxious to health.*—Whoever voluntarily vitiates the atmosphere in any place so as to make it noxious to the health of persons in general, dwelling or carrying on business in the neighbourhood, or passing along a public way, shall be punished with fine which may extend to five hundred rupees.

S. 284. *Negligent conduct with respect to poisonous substance.*—Whoever does, with any poisonous substance, any act in a manner so rash or negligent as to endanger human life, or to be likely to cause hurt or injury to any person, or knowingly or negligently omits to take such order with any poisonous substance in his possession as is sufficient to guard against probable danger to human life from such poisonous substance, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 285. *Negligent conduct with respect to fire or combustible matter.*—Whoever does, with fire or any combustible matter, any act so rashly or negligently as to endanger human life, or to be likely to cause hurt or injury to any other person, or knowingly or negligently omits to take such order with any fire or any combustible matter in his possession as is sufficient to guard against any probable danger to human life from such fire or combustible matter, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 286. *Negligent conduct with respect to explosive substance.*—Whoever does, with an explosive substance, any act so rashly or negligently as to endanger human life, or to be likely to cause hurt or injury to any other person, or knowingly or negligently omits to take such order with any explosive substance in his possession as is sufficient to guard against any probable danger to human life from that substance, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 287. *Negligent conduct with respect to machinery.*—Whoever does, with any machinery, any act so rashly or negligently as to endanger human life, or to be likely to cause hurt or injury to any other person or knowingly or negligently omits to take such order with any machinery in his possession or under his care as is sufficient to guard against any probable danger to human life from such machinery, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 288. *Negligent conduct with respect to pulling down or repairing buildings.*—Whoever, in pulling down or repairing any building, knowingly or negligently omits to take such order with that building as is sufficient to guard against any probable danger to human life from the fall of that building, or of any part thereof, shall be punished with imprisonment of either description for a term which may extend to six

months, or with fine which may extend to one thousand rupees, or with both.

S. 289. *Negligent conduct with respect to animal.*—Whoever knowingly or negligently omits to take such order with any animal in his possession as is sufficient to guard against any probable danger to human life, or any probable danger of grievous hurt from such animal, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

S. 290. *Punishment for public nuisance in cases not otherwise provided for.*—Whoever commits a public nuisance in any case not otherwise punishable by this Code, shall be punished with fine which may extend to two hundred rupees.

S. 291. *Continuance of nuisance after injunction to discontinue.*—Whoever repeats or continues a public nuisance having been enjoined by any public servant who has lawful authority to issue such injunction not to repeat or continue such nuisance, shall be punished with simple imprisonment for a term which may extend to six months, or with fine, or with both.

APPENDIX D.

Sections of Criminal Procedure Code relating to Prevention of Offences of Public Nuisances.

S. 133. *Conditional order for removal of nuisance.*—(1) Whenever a District Magistrate, a Sub-divisional Magistrate or a magistrate of the first class considers, on receiving a police-report or other information and on taking such evidence (if any) as he thinks fit,

that any unlawful obstruction or nuisance should be removed from any way, river or channel which is or may be lawfully used by the public, or from any public place, or

that the conduct of any trade or occupation, or the keeping of any goods or merchandise, is injurious to the health or physical comfort of the community, and that in consequence such trade or occupation should be prohibited or regulated or such goods or merchandise should be removed or the keeping thereof regulated, or

that the construction of any building, or the disposal of any substance, as likely to occasion conflagration or explosion, should be prevented or stopped, or

that any building, tent or structure, or any tree is in such a condition that it is likely to fall and thereby cause injury to persons living or carrying on business in the neighbourhood or passing by, and that in consequence the removal, repair or support of such building, tent or structure, or the removal or support of such tree, is necessary, or

that any tank, well or excavation adjacent to any such way or public place should be fenced in such manner as to prevent danger arising to the public, or

that any dangerous animal should be destroyed, confined or otherwise disposed of,

such Magistrate may make a conditional order requiring the person causing such obstruction or nuisance, or carrying on such trade or occupation or keeping any such goods or merchandise, or owning, possessing or controlling such building, tent, structure, substance, tank, well or excavation, or owning or possessing such animal or tree, within a time to be fixed in the order,

to remove such obstruction or nuisance; or

to desist from carrying on, or to remove or regulate in such manner as may be directed, such trade or occupation; or

to remove such goods or merchandise, or to regulate the keeping thereof in such manner as may be directed; or

to prevent or stop the erection of, or to remove, repair or support, such building, tent or structure; or

to remove or support such tree; or

to alter the disposal of such substance; or

to fence such tank, well or excavation as the case may be; or

to destroy, confine or dispose of such dangerous animal in the manner provided in the said order; or, if he objects so to do,

to appear before himself or some other Magistrate of the first or second class, at a time and place to be fixed by the order, and move to have the order set aside or modified in the manner hereinafter provided.

(2) No order duly made by a Magistrate under this section shall be called in question in any Civil Court.

Explanation.—A 'public place' includes also property belonging to the State, camping grounds and grounds left unoccupied for sanitary or recreative purposes.

S. 134. *Service or notification of order.*—(1) The order shall, if practicable, be served on the person against whom it is made, in manner herein provided for service of a summons.

(2) If such order cannot be so served, it shall be notified by proclamation, published in such manner as the Local Government may by rule direct, and a copy thereof shall be stuck up at such place or places as may be fittest for conveying the information to such person.

S. 135. *Person to whom order is addressed to obey or show cause or claim jury.*—The person against whom such order is made shall—

(*a*) perform, within the time and in the manner specified in the order, the act directed thereby; or

(*b*) appear in accordance with such order and either show cause against the same, or apply to the Magistrate by whom it was made to appoint a jury to try whether the same is reasonable and proper.

S. 136. *Consequence of his failing to do so.*—If such person does not perform such act or appear and show cause or apply for the appointment of a jury as required by s. 135, he shall be liable to the penalty prescribed in that behalf in s. 188 of the Indian Penal Code, and the order shall be made absolute.

S. 137. *Procedure where he appears to show cause.*—(1) If he appears and shows cause against the order, the Magistrate shall take evidence in the matter as in a summons-case.

(2) If the Magistrate is satisfied that the order is not reasonable and proper, no further proceedings shall be taken in the case.

(3) If the Magistrate is not satisfied, the order shall be made absolute.

S. 138. *Procedure where he claims jury.*—(1) On receiving an application under s. 135 to appoint a jury, the Magistrate shall—

(*a*) forthwith appoint a jury consisting of an uneven number of persons not less than five, of whom the foreman and one-half of the remaining members shall be nominated by such Magistrate, and the other members by the applicant;

(*b*) summon such foreman and members to attend at such place and time as the Magistrate thinks fit and

(*c*) fix a time within which they are to return their verdict.

(2) The time so fixed may, for good cause shown, be extended by the Magistrate.

S. 139. *Procedure where jury finds Magistrate's order to be reasonable.*—(1) If the jury or a majority of the jurors find that the order of the Magistrate is reasonable and proper as originally made, or subject to a modification which the Magistrate accepts, the Magistrate shall make the order absolute, subject to such modification (if any).

(2) In other cases no further proceedings shall be taken under this Chapter.

S. 139 A. *Procedure where existence of public right is denied.*—(1) Where an order is made under s. 133 for the purpose of preventing obstruction, nuisance or danger to the public in the use of any way, river, channel or place, the Magistrate shall, on the appearance before him of the person against whom the order was made, question him as to whether he denies the existence of any public right in respect of the way, river, channel or place, and if he does so, the Magistrate shall, before proceeding under s. 137 or s. 138, inquire into the matter.

(2) If in such inquiry the Magistrate finds that there is any reliable evidence in support of such denial, he shall stay the proceedings until the matter of the existence of such right has been decided by a competent Civil Court; and, if he finds that there is no such evidence, he shall proceed as laid down in s. 137 or s. 138, as the case may require.

(3) A person who has, on being questioned by the Magistrate under sub-section (1), failed to deny the existence of a public right of the nature therein referred to, or who, having made such denial, has failed to adduce reliable evidence in support thereof, shall not in the subsequent proceedings be permitted to make any such denial, nor shall any question in respect of the existence of any such public right be inquired into by any jury appointed under s. 138.

S. 140. *Procedure on order being made absolute.*—(1) When an order has been made absolute under s. 136, s. 137 or s. 139, the Magistrate shall give notice of the same to the person against whom the order was made, and shall further require him to perform the act directed by the order within a time to be fixed in the notice, and inform him that, in case of disobedience, he will be liable to the penalty provided by s. 188 of the Indian Penal Code.

(2) If such act is not performed within the time fixed, the Magistrate may cause it to be performed, and may recover the costs of performing it, either by the sale of any building, goods or other property removed by his order, or by the distress and sale of any other moveable property of such person within or without the local limits of such Magistrate's jurisdiction. If such other property is without such limits, the order shall authorize its attachment and sale when endorsed by the Magistrate within the local limits of whose jurisdiction the property to be attached is found.

(3) No suit shall lie in respect of anything done in good faith under this section.

S. 141. *Procedure on failure to appoint jury or omission to return verdict.*—If the applicant, by neglect or otherwise, prevents the appointment of the jury or if from any cause the jury appointed do not return their verdict within the time fixed or within such further time as the Magistrate may in his discretion allow, the Magistrate may pass such order as he thinks fit, and such order shall be executed in the manner provided by section 140.

S. 142. *Injunction pending inquiry.*—(1) If a Magistrate making an order under section 133 considers that immediate measures should be taken to prevent imminent danger or injury of a serious kind to the public, he may, whether a jury is to be, or has been, appointed or not, issue such an injunction to the person against whom the order was made, as is required to obviate or prevent such danger or injury pending the determination of the matter.

(2) In default of such person forthwith obeying such injunction, the Magistrate may himself use, or cause to be used, such means as he thinks fit to obviate such danger or prevent such injury.

(3) No suit shall lie in respect of any thing done in good faith by a Magistrate under this section.

S. 143. *Magistrate may prohibit repetition or continuance of public nuisance.*—A District Magistrate or Sub-divisional Magistrate, or any other Magistrate empowered by the Local Government or the District Magistrate in this behalf, may order any person not to repeat or continue a public nuisance, as defined in the Indian Penal Code or any special or local law,

APPENDIX E.

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6. Preventive Medicine and Hygiene by Rosenau.
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12. Students' Text-Book of Hygiene by Wilson.
13. The Principles of Hygiene by Simpson.
14. Bedford's Elementary Hygiene.
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16. Text-Book of Public Health by E. W. Hope and C. O. Stallybrass.
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41. Monographic Medicine, Vol. IV, by Barker.
42. Fevers in the Tropics by Sir Leonard Rogers.
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44. Anophelene Mosquitoes of India by James and Liston.
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